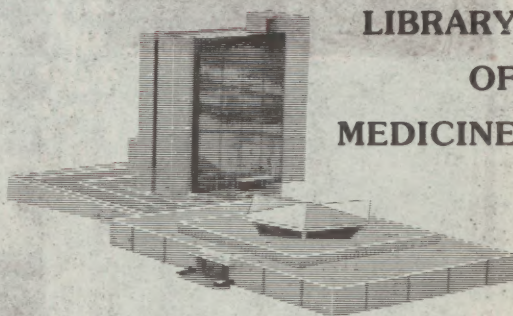


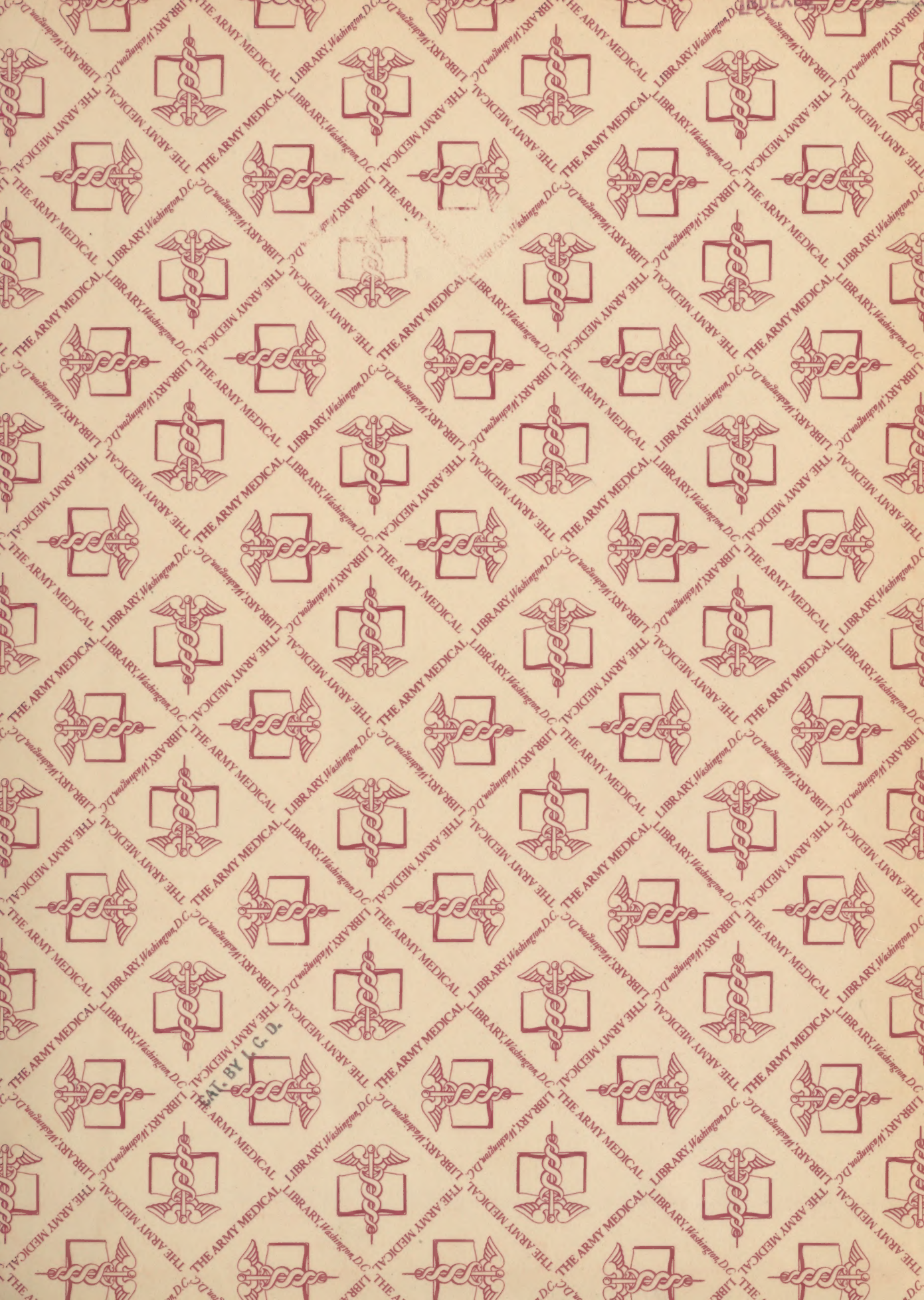


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A HISTORY OF WARTIME RESEARCH AND DEVELOPMENT

OF

MEDICAL FIELD EQUIPMENT

by

John B. Johnson, Jr.
1st Lt., M.A.C.

and

Graves H. Wilson
1st Lt., M.A.C.

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<i>Frank B. Rogers</i>	

(This is not the final form in which the subject of research and development of medical field equipment will be covered in THE HISTORY OF THE MEDICAL DEPARTMENT DURING WORLD WAR II. This monograph has not been reviewed by the Historical Division, War Department Special Staff.)

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30 June 1946

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A REVIEW OF MEDICAL RESEARCH AND DEVELOPMENT

OF

MEDICAL FIELD EQUIPMENT

John B. Johnson, Jr.
2nd Lt., U.S.A.

CLASSIFICATION OF WORK
UNCLASSIFIED
DATE
BY
REVIEWER
<i>Frank R. Johnson</i>

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Division, War Department Special Staff.)

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THE HISTORICAL

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1. This report is a summary of the information received from the various sources mentioned in the preceding paragraph. It is intended to provide a general overview of the situation and to highlight the key points of interest.

2. The information received from the various sources is as follows: (a) The first source reported that the situation was generally stable, with no major developments. (b) The second source reported that there had been a significant increase in the number of incidents, particularly in the area of the capital. (c) The third source reported that the situation was becoming increasingly volatile, with a number of major incidents reported.

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PREFACE

I. Authority.

This monograph is submitted in compliance with Army Service Forces Memorandum, dated 31 July 1944, (see Appendix Q) directing each Chief of Service to prepare an illustrated and documented history of wartime research and development.

On 12 December 1945, by 1st Indorsement from Control Division, Army Service Forces to The Surgeon General, a completion date of 30 June 1946 was authorized for this undertaking.

II. Scope and Method.

A. Selection of Projects.

During World War II, Army medical research and development was carried on at seven specialized Medical Department laboratories, at numerous other military installations including general and station hospitals, and at civilian laboratories under Army control. Experimentation was also conducted in collaboration with other Technical Services, with the United States Navy, with certain federal agencies such as the Office of Scientific Research and Development, and with private industry.

Although a careful sampling of all of these various projects would have been highly desirable, it was necessary to reject this method of approach because of the particular circumstances under which the present monograph was prepared. Uncertainty as to the amount of time which would be available for the study, limitations both as to funds and personnel, and the evident lack of adequate secondary source material dictated the adoption of a plan which would restrict the scope of the inquiry to much more manageable limits.

It was subsequently decided, therefore, that research efforts should be limited to an investigation of a single broad field of experimentation. All major research programs were then surveyed on these four bases: (1) relative importance, as measured by battle utility of the items developed, time and funds expended, number of personnel involved; (2) amount and availability of primary source data; (3) accessibility of laboratories concerned; and (4) extent of technical as well as administrative participation by the Medical Department. As a result of this

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analysis, the development of medical field equipment was selected as the subject of this monograph.

After consultation with officers of the Technical Division of The Surgeon General's Office and representatives of the Medical Department Equipment Laboratory at Carlisle Barracks, Pennsylvania, it was further decided (1) to eliminate from consideration all "informal" field equipment projects, inasmuch as these ordinarily involved only slight modification of existing commercial items, and (2) to select as the first major topic of study the Medical Department Litter Program. It was felt that this program was of primary importance because of its basic connection with the entire process of casualty evacuation.

Responsibility for the selection of specific litter projects rests solely with the author of this portion of the monograph. Separate chapters have been devoted to the straight pole and folding pole litters because of their all-purpose character, their procurement importance, and the extensiveness of their use overseas. Out of a total of seven projects dealing with miscellaneous or special-purpose litters and litter adapters, three were chosen for inclusion in the final chapter of this section. Here the attempt was made to include unsuccessful as well as successful projects, and to include at least one project involving extensive collaboration with agencies outside the Medical Department.

In order to make the most efficient use of the time remaining, after completing the history of the Medical Department Litter Program the authors requested the Director of the Technical Division and the Director of the Medical Department Equipment Laboratory to prepare a selective list of additional projects which, from the standpoint of significance and representativeness, especially merited inclusion in this history. Upon receipt of these independent selections, a consolidated list was prepared from which six projects, designated in the monograph as the Medical Department Vehicle Program, were chosen. These six projects were all closely related, formed a complete series, and, it was estimated, could be completed by 30 June 1946.

B. Collection of Data.

The documentary material employed in the preparation of this monograph has been drawn primarily, though not exclusively, from Medical Department sources. Within The Surgeon General's Office, pertinent files of the Historical Division; all branches of the Technical Division, including the office of the Division Director; and both the classified and unclassified sections of the Record Room were extensively

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examined for every project investigated.

The files of other Surgeon General's Office agencies, such as the Dental Division and the Optical and Artificial Eyes Section of the Distribution Division, were carefully surveyed whenever a project in which these agencies had participated was under consideration. The Publications Branch of the Administrative Service was regularly consulted for information regarding Army Regulations, War Department and Army Service Forces Circulars and Memoranda, and Tables of Organization and Equipment. Military periodicals and reference books were obtained, when needed, from The Surgeon General's Reference Library.

Two other Medical Department agencies were especially valuable sources of information: the Army Medical Purchasing Office in New York City and the Medical Department Equipment Laboratory at Carlisle Barracks, Pennsylvania. Through correspondence with the former, essential facts regarding production contracts and delivery schedules were obtained. From the latter, complete technical data relating to the substantive aspects of research, development, and field testing were secured. During the first half of the study, individual project files were obtained intact from the Equipment Laboratory on a temporary loan arrangement. During the second half of the study, the Laboratory actively assisted in the undertaking by preparing, under the guidance of the Historical Division, individual project histories based on the material in its files.

While agencies outside the Medical Department were not consulted as a matter of routine, such sources were investigated whenever a serious gap existed in the material. During the course of the study special record searches of this type were made of the files of the Assistant Chief of Staff, G-4; Headquarters, Army Service Forces; the Research and Development Division of Ordnance Department; the Office of Scientific Research and Development; the National Inventors Council; and the National Archives.

Although principal research emphasis has been placed on the collection and examination of recorded data, considerable additional information was obtained through personal interview. Whenever necessary, either for purposes of general orientation or for answers to specific questions, interviews were held with key personnel--particularly with the officials of the Technical Division of The Surgeon General's Office and members of the staff of the Medical Department Equipment Laboratory.

Finally, the authors have made a special attempt to familiarize themselves with the physical details of the

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field items discussed. All available photographs and many drawings were carefully studied, and, in addition, first-hand inspections were made of the field items on display both in the Sample Room of The Surgeon General's Office and in the Museum of the Medical Department Equipment Laboratory.

C. Limitations of Data.

While a conscientious effort has been made to obtain, within the time allotted, the maximum amount of relevant data, both written and unwritten, the factual evidence upon which this study is based has, nevertheless, a number of limitations. In the first place, as indicated above, sources outside the Medical Department have been examined only partially, not exhaustively. Secondly, as a result of frequent office reorganizations, turnover of personnel, and other causes, even those files which have been carefully examined have been found to be not altogether complete.

In the third place, many events occurred during the war years of which no written record was ever made. Actions taken as a result of telephone conversations, informal meetings, and conferences are among those that fall within this category. Although efforts were made to fill these gaps by means of interviews, reconstruction of these unrecorded happenings was not always possible. In several instances the officers concerned had already been transferred to other posts, had died, or had been separated from the service. In others, conflicting interpretations were sometimes received which, in the absence of other data, could not be satisfactorily resolved.

Finally, it is recognized by the authors that certain of the events which have been described in this monograph are fully explainable only in terms of larger events which could not, in more than a few instances, be adequately studied. War plans, troop movements, shortages of strategic materials, organizational changes, and budget and personnel allotments, to mention a few, have all affected the course of medical research and development. Comprehensive coverage of all of these external factors was manifestly impossible.

Despite these several limitations, however, it is believed by the authors that the data upon which this historical account has been based is sufficiently representative and complete to warrant the formulation of certain tentative conclusions regarding the conduct of Medical Department research and development. These generalizations, directly induced from all the material at hand and arrived at after approximately eighteen months of study, are presented in the

final chapter of this monograph.

D. Treatment of Material.

The individual project histories that follow are not exclusively technical in content. Instead, with the approval of Control Division, Army Service Forces, the attempt has been made to describe as accurately and as comprehensively as possible all major aspects of the research and development process. Typically, this method of approach has yielded the following subject matter headings for each item or program discussed: (1) historical background; (2) project initiation; (3) development phase; (4) standardization phase; (5) procurement phase; and (6) project evaluation. The complete project outline employed in this study is presented as Appendix R.

It will be noted that each of the development projects included in this monograph has been discussed in considerable detail. A detailed rather than general treatment of the material was necessary for two reasons. In the first place, the basic directive stipulated that a "source book" type of history be prepared. Consequently, except for reports which were too lengthy to be conveniently incorporated into the body of the narrative and which, therefore, have been included as separate appendices, many essential documents have been extensively quoted or paraphrased in the text of the history. Secondly, the particular nature of the source material itself was such as to preclude satisfactory generalized treatment. Individual committee reports, correspondence with manufacturers, specifications, drawings, equipment lists, and the like were often of sufficient importance to warrant inclusion in the monograph but were too highly technical to be presented other than in detail.

E. Documentation.

The documentation of this monograph follows conventional practices. Statements of fact not commonly known and all direct quotations are cited in footnotes which have been placed at the end of each chapter. The source or location of the document concerned is given in parentheses. When copies of the same document are to be found in the files of different organizations, an attempt has been made to give the location of the more central and, presumably, more permanent file. In instances where units of The Surgeon General's Office have undergone reorganization since the original record search was made, the name of the organization at present having custody of the files in question has been cited.

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F. Authorship.

Except for the Preface and Conclusion, which represent a joint effort, all other chapters of this monograph have been individually written. All chapters of Part I and Chapters 6, 7, and 9 of Part II were prepared by Lieutenant Johnson. Chapters 5, 8, and 10 of Part II were prepared by Lieutenant Wilson.

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LIST OF ABBREVIATIONS USED IN FOOTNOTES

A. G. (<u>or</u> T. A. G.)	The Adjutant General
A. G. F.	Army Ground Forces
A. G. O.	Office of The Adjutant General
A. M. C.	Army Medical Center
A. M. P. O.	Army Medical Purchasing Office
A. M. R. & D. Bd.	Army Medical Research and Development Board
A. S. F.	Army Service Forces
CBI	China-Burma-India Theater of Operations, United States Army
C. G. (<u>or</u> T. C. G.)	The Commanding General
ETO (<u>or</u> ETOUSA)	European Theater of Operations, United States Army
FM	Field Manual
M. D. E. L.	Medical Department Equipment Laboratory
M. D. T. C.	Medical Department Technical Committee
M. F. S. S.	Medical Field Service School
NATOUA	North African Theater of Opera- tions, United States Army
O. Q. M. G.	Office of The Quartermaster General

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POA	Pacific Ocean Area
P. O. E.	Port of Embarkation
S. G. (<u>or</u> T. S. G.)	The Surgeon General
S. G. O.	Office of The Surgeon General
S. O. S.	Services of Supply
SWPA	Southwest Pacific Area
T/O & E	Table of Organization and Equipment
W. D. G. S.	War Department General Staff
W. P. B.	War Production Board

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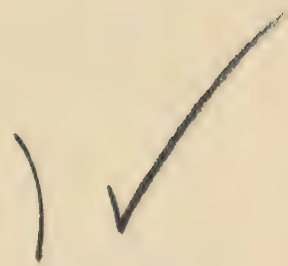
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PART I

MEDICAL DEPARTMENT LITTER PROGRAM



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INTRODUCTION

The design and development of a satisfactory military litter is a far more complex task than is generally supposed. For this reason a brief introduction, surveying the problem as a whole, is presented here. It is hoped that future research and development personnel, confronting for the first time the specialized problem of litter construction, may find the following discussion helpful.

I. Difficulties Common to World War I and World War II.

The difficulties facing the Medical Department in April, 1941, when the present litter program was initiated,¹ can be conveniently grouped into two major categories. First of all, there are those factors which have shaped and to a certain extent inhibited litter research and development throughout our military history.

A. Interdependence of Parts.

The Army litter is not a simple one-piece mechanism. Although decidedly less complicated in construction than the old ash pole litter of World War I, the standard litter of today consists of a canvas cover, two litter poles, four handles, drive-pins to secure the handles, two spreader bars, four sets of stirrups, stirrup bolts, stirrup base blocks and swivel blocks, cap screws for the swivel blocks, and litter securing straps.²

Each of these components is intimately related in its functioning to one or more of the others. Decrease the length of the litter poles without altering the position of the running gear and the knees of the litter bearers will be striking against the undercarriage. Reduce the diameter of the poles and the saddle which holds the stirrup in place will have to be redesigned. Increase the diameter of the poles and the width of the canvas will be affected. Reduce the width of the canvas and the spreader bar will fail to lock.

For those charged with the responsibility for litter research and development the principle of the interdependence of parts is basic. A proposal to alter, however slightly, even one component of the litter must be weighed most carefully and an exhaustive effort made to discover the effect of this single change upon all the other directly and

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indirectly related parts.

B. Critical Shortages of Material.

In wartime the existence of critical shortages of material is inevitable. Enemy invasion of neutral or Allied territory may result in the sharp reduction or, at times, the complete curtailment of certain basic sources of supply. Unusual demand for a particular raw material, labor difficulties, transportation tie-ups, and a thousand other factors contribute to make critical shortages a common occurrence in times of national emergency.

The most common effect of a shortage in material is, of course, simply to force abandonment or avoidance of that particular material in manufacture. Unless an adequate priority is obtained, the only recourse for the Medical Department or any other agency is to develop as rapidly as possible satisfactory substitutes. The time element in this instance is crucial. Even when the shortage is foreseen by as much as two years, research and development personnel are likely to find themselves in a desperate race against time.

The aluminum shortage of 1942 was foreseen by the Medical Department at least as early as 1940, and in April of the following year a litter project was initiated to develop substitutes for that material.³ Nevertheless, despite intensive and continuous investigation, it was not until January, 1942--the same month which witnessed the official announcement of major restrictions governing aluminum procurement⁴--that a satisfactory substitute for the aluminum litter pole and undercarriage had been found.⁵ Moreover, it was not until June, 1942, that the depots began to receive even small quantity shipments of the new steel litter.⁶

A somewhat less common but equally restrictive effect of shortages is involuntary "freezing" of an item. Where the shortage is potential rather than actual, and current market conditions are favorable, foresightedness may dictate over-purchase of the component affected in order to build up a stock-pile reserve. This action, however, has the immediate effect of fixing for a relatively extended period of time the specifications of the item in question. Recalling our discussion of the interdependence of parts, it is not difficult to perceive the effect this stabilizing of one component may have on modification of litter design as a whole.

Canvas furnishes a striking illustration of this

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principle. Even in the early years of the war, canvas was a potentially critical item and the Medical Department, anticipating that its future requirements would be heavy, purchased large quantities of canvas litter covers. Specifications, of course, were drawn to fit the standard litter in use at that time. These quantity orders, however, resulted not only in fixing for some years to come the shape and size of litter covers, but also had the further effect of fixing just as unalterably the dimensions of the litter poles. For with canvas of a specified width and length with side hems of a certain depth, only a pole of a specific size will fit snugly into the folds.

Obviously such a combination of factors may, at least temporarily, seriously narrow the field of research and development possibilities. In 1942 experiments were being conducted with resin bonded plytube poles. It was found necessary to increase their diameter beyond that of the standard litter pole in order to secure a strength equal to that of the aluminum which was to be replaced. In answer to the manufacturer's telegraphic request that specifications regarding litter pole dimensions be liberalized to permit procurement of a slightly larger tube,⁷ the Surgeon General's Office was forced to reply:

Fittings are not the only reason why the dimensions of the pole are set. A number of other factors enter into the size and dimensions of the poles, one of which is the size of the loop in the canvas which cannot be changed since we have millions of pieces of this canvas already procured.⁸

C. Patient Comfort and Litter Bearer Fatigue.

The human factors of patient comfort and litter bearer fatigue are essential considerations in every litter development project. The shape, angle, and texture of the pole handles may spell the difference for the litter bearer between a comfortable normal carry and one that blisters the hands and knots the back muscles. The shape and position of the spreader bar--its proximity to the surface of the canvas, whether it is straight or curved--will affect the comfort and, in certain fracture cases, even the future recovery of the patient. Litter poles which are too rigid give the casualty load a kind of dead weight heaviness which is tiring for the litter bearers, and make the ride an exceedingly bumpy and often acutely painful one for the patient. Litter poles which are too resilient tend to bounce the patient as well as to maximize the weight strain on the bearers.

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Not infrequently, of course, the criteria of patient comfort and litter bearer fatigue stand in opposition to one another and the only satisfactory solution is a compromise. If, for example, the weight of the litter poles is excessive the litter bearers suffer, personnel replacements in the field become an acute problem, and long litter hauls are out of the question. If, on the other hand, the poles are too light they are likely to take a permanent bow or set, or even to snap under a normal casualty load thereby endangering the life of the patient. Obviously in such cases the answer lies in the direction of some feasible intermediate position.

D. Adaptability to Mass Production.

In supplying an army of eight million men, fabrication by hand is out of the question. Not infrequently pilot models representing definite structural advantages must be rejected because of their inadaptability to mass production. In many instances stretchers which are entirely suitable for small-scale civilian use cannot be considered by the Army because of their intricate designs or their use of costly or scarce materials.

An item must not only be adaptable to mass production, but the length of time required before actual production can begin is a further qualifying factor. Whatever the intrinsic value of the improvements involved, a litter design which requires substantial retooling on the part of the manufacturer before actual fabrication can begin will be of little use in a war of short duration. The realistic evaluation of litter ideas is promised always on careful weighing of the time factor.

In AR 850-25, the basic regulation governing wartime research and development, the War Department states its position in this respect as follows:

It is most essential in all states of development work that adaptability of the item to quantity production be considered as one of the most important requirements of the design. For this reason the adoption of commercial items or their adaptation with the fewest practicable modifications, whenever such procedure will satisfy military requirements, is a policy of the War Department.⁹

E. Ruggedness and Simplicity of Construction.

Although as we have seen, litter development in-

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volves the careful weighing of a multiplicity of complex factors, the end result must above all be simple. Enlisted men working in depots and warehouses, serving in the field as litter bearers and maintenance men, are seldom expert mechanics. Therefore, to be thoroughly effective for their use, a litter must be simple to operate, simple to take apart and repair, simple to reassemble, and simple to collapse and secure for shipping and storage.

By the same token a litter must be sufficiently rugged to withstand the roughest treatment under field conditions. An empty litter may not receive gentle handling in the excitement of battle. It may often be thrown, not carefully loaded into cargo trucks and ambulances. It may be carelessly dropped on rocky ground and on concrete high-ways. It may be left in the field, exposed to wind, rain, and snow. Consequently the litter must be sturdy. Mud and sand must have little or no effect on the hinge and stirrup bearings. Finally, the occupied litter must be strong enough to withstand the shock and weight of casualty loading and unloading, as well as long ambulance hauls over rough terrain.

II. Difficulties Unique to World War II.

The problems which have just been enumerated are not peculiarly characteristic of the present war but applied with equal force to litter development during World War I. There are, however, two major factors which may be described as the special products of the uniquely mechanistic and global nature of the war we are now waging.

A. Interchangeability of Parts.

The global nature of the present war has raised problems of variety and quantity unknown in 1918. In the closing months of World War I, when research and development activities had reached their peak, only two types of litters were being purchased in quantity by the United States Army-- (1) The Regulation Canvas, a heavy, 22 pound ash pole litter with tacked-on canvas and cast iron running gear, and (2) The Stokes, developed by the United States Navy, a basket-type litter supported by soft steel rods and braces, and lined with chicken wire.¹⁰

In the present war nine litters are listed in the Medical Supply Catalogue.¹¹

784400 Litter (World War I model; now
Limited Standard)

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9934700 Litter, ambulance cot: Bomgardner type
9935000 Litter, straight, aluminum
9936000 Litter, canvas, semi-rigid
9936200 Litter, folding, wood
9936600 Litter, straight, wood, M-1943
9937600 Litter, straight, steel
9937000 Litter, folding, aluminum
9938500 Litter, metal, Stokes: airplane
(modified World War I model)

In addition to the foregoing items, two more litters have been very recently developed, one of which has already been standardized for procurement.¹²

1. Litter, mountain: basket type with wood base
2. Litter, poleless nylon, M-1

Some conception of the magnitude of the Medical Department's current litter program can be obtained from the following statistics covering the first nine months of 1943, and relating to the four litter items under the heaviest procurement at that time.¹³

	<u>Deliveries</u> <u>1 Jan. 43 to</u> <u>30 Sep. 43</u>	<u>Contracts not</u> <u>delivered</u> <u>30 Sep. 43</u>	<u>Total</u> <u>30 Sep. 43</u>
Litter, folding, wood	25,485	47,773	73,258
Litter, straight, steel	334,233	89,786	424,009
Litter, folding, aluminum	12,604	484	13,088
Litter, metal	68,420	258,731	327,151
Total	440,732	396,774	837,506

As of 25 January 1945, considering only those litters which had been developed and placed under procurement since the outbreak of World War II, actual deliveries alone amounted to 555,900.¹⁴

	<u>Total deliveries</u> <u>25 Jan. 1945</u>
9936000 Litter, canvas, semi-rigid	10,000
9936200 Litter, folding, wood	69,220
9936600 Litter, straight, wood, M-1943	5,363
9937600 Litter, straight, steel	471,317
Total	555,900

The mere existence of such a wide variety of litters, procured in such quantity, has posed problems unique to this war. Under the system of property exchange as employed overseas, the litter typically serves as a bed on which the casualty may rest from the time he is taken from the field by the front-line litter bearers until he reaches his terminal point

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in the chain of evacuation. In order to replace the litter thus removed, each echelon sends forward a litter in exchange.

Consider what effect a variety of litter types has upon such a system. At any point in the process and at any time, steel litters may be received in exchange for aluminum, or aluminum for wood, and so on. Clearly, without a high degree of interchangeability of parts, the entire evacuation process is likely to break down. Field maintenance becomes impossible, for no forward installation can conceivably keep on hand replacement parts sufficient to service even four (the number of straight litters alone which are now in field use), much less ten completely different types.

It has been necessary, therefore, to consider each new litter proposal in the light of its conformity or non-conformity with litter components already in use. Where procurement requirements are light and where the using agency is performing a rather highly specialized function, considerable deviation has been permitted. But from time to time it has been compellingly necessary to design universal undercarriages which will permit complete interchangeability of parts between all, or nearly all, of the litters in use at overseas installations. Several such undercarriages have been constructed during this war and plans are currently going forward to construct a new one.

B. Adaptability to Land, Sea, and Air Transportation.

Not only the global but also the mechanistic character of the present war has given rise to difficulties which were largely non-existent in our earlier wars. In the days when litter patients were evacuated solely by hand-carry, adaptability to "transportation factors" could be achieved merely by designing a more comfortable handle or perhaps an adjustable sling strap for the litter bearers. During the whole of World War I, one change only was required in the ash pole litter; a change in the location of the braces to a point 7 inches nearer the pole ends to adapt the litter to the new wheeled litter carrier which was then being purchased in France.¹⁵

Today, casualties are not only being evacuated by hand-carry, but by pack animals, skis, toboggans, $\frac{1}{2}$ -ton jeeps, cargo trucks, cross-country ambulances, hospital trains, airplanes, and seacraft. Furthermore, completely equipped motorized and airborne hospitals are now in operation in forward positions near the combat zone. The litter of today must be so designed that it will conform to the individual fittings of each of these widely varying forms of transportation as well as each of the steadily increasing number of mobile

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operating units. The adaptability factor is a constant complication that has taxed the resourcefulness of litter development personnel to the utmost.

CONCLUSION

Seven major factors, involved in the over-all problem of litter construction, have been emphasized in this preliminary discussion: (1) Interdependence of Parts, (2) Critical Shortages of Material, (3) Patient Comfort and Litter Bearer Fatigue, (4) Adaptability to Mass Production, (5) Ruggedness and Simplicity of Construction, (6) Interchangeability of Parts, and (7) Adaptability to Land, Sea, and Air Transportation.

The foregoing list is by no means exhaustive, but it is hoped that it will provide a helpful frame of reference for the more detailed studies which are to follow. The development of a satisfactory military litter, in view of the many variables involved, constitutes a highly specialized task of research and engineering. The manner in which the Medical Department has met this challenge will be the subject of the chapters to follow.

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FOOTNOTES TO CHAPTER I

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- ²Medical Supply Catalog, Army Service Forces Catalog MED 3,
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- ⁴Conservation Directive No. 14, "Conservation of Aluminum",
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- ⁵See Chap. II.
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¹³ Cited in Summary of "Latter" by Paul I. Robinson, Col.,
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CHAPTER II

THE STRAIGHT POLE LITTER

I. Historical Background.

The straight pole litter of the United States Army has been the backbone of our system of medical evacuation for more than 85 years. However, throughout this period, both in terms of construction and design the litter has been in an almost constant state of evolution. In order, therefore, to evaluate properly the many physical changes that have taken place in the straight pole litter since the outbreak of the present war, it is necessary to view this most recent period of development in its larger historical perspective.

A. The Period from 1860-1918.¹

Prior to 1860, our knowledge of the type of device employed in removing casualties from the field of battle is fragmentary. There appears to be some evidence that during the Revolutionary War wheel barrows and hand barrows (see Fig. 1) were used. However, the precise date of the adoption of the present litter-type of conveyance is still a matter of speculation. General Roy C. Heflebower, who investigated this subject extensively in 1927, was unable to find any descriptions of the carrying devices employed in the War of 1812, the various Indian campaigns which followed, or the Mexican War.²

1. The Satterlee Litter (1860).

It is with the Satterlee litter, used during the early months of the Civil War, that recorded and detailed history of the Army straight pole litter begins. The Satterlee litter (see Fig. 2) weighed 24-1/2 pounds and was 27 inches wide. Its seasoned red ash poles were round, measuring 1-1/2 inches in diameter, and were 8 feet 9 inches in length. The cover, which was 5 feet 10 inches long, consisted of two pieces of canvas sewed in the center with a flat seam. Hems, 7-1/2 inches wide, were provided on each side of the canvas for the poles to pass through. At each end, the cover was laced to a wooden cross bar by means of tarred rope loops which fit over three small pins. The cross bars, made of seasoned white oak, were fitted against tiny wrought iron hands which were riveted to the poles as shoulders for the cross bars to strike against. The undercarriage was composed

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of two pieces of wrought iron, 6 feet long, so curved as to form legs for the litter to rest upon as well as sockets for the poles.

Compared to the primitive hand barrow, the Satterlee litter represented an enormous improvement both in structural design and field effectiveness. It was more comfortable for the patient, was considerably less bulky and cumbersome for the litter bearers to handle, occupied far less storage and shipping space, and required for its construction only a fraction of the material needed for the hand barrow. However, under actual war conditions, the Satterlee litter exhibited certain defects which were to be largely eliminated in the course of subsequent litter development.

In the first place, the extremely long poles of the Satterlee model made the litter awkward to handle and tended to maximize the weight strain on the bearers. Similarly the huge looping feet, raising the surface of the litter much higher off the ground than was necessary for patient protection, added considerably to the over-all weight. Because of the rigid cross bars, before the litter could be collapsed it had to be taken apart and reassembled, an operation that was time consuming in the extreme. Finally, the use of two-piece canvas for the litter cover, with its complicated lacing arrangement, posed maintenance problems of a particularly troublesome nature.

The Satterlee design, however, made one notable contribution to subsequent litter evolution, although nearly 75 years were to elapse before this idea was to be incorporated again into Medical Department specifications. This was the "slip-on" arrangement for attaching the canvas cover to the side poles, using hem loops in the canvas instead of tacks or bolted metal strips. In 1934 this feature was revived, and it continues in use down to the present day.

2. The Halstead Litter (c. 1861).

In view of the disadvantages cited above, it is not surprising to learn that a thoroughgoing modification of the Satterlee litter was soon forthcoming.

In actual war conditions the Satterlee litter did not prove satisfactory....It was soon superseded by a folding type known as the Halstead litter. This litter was a great improvement over its predecessor and about 40,000, or 80 per cent of the litters purchased during the Civil War were of this type.³

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The Halstead litter (see Fig. 3) weighed 23-3/4 pounds, and was 23-1/2 inches wide. Its poles, which were of seasoned white ash, were 8 feet long, and were square in shape. The side poles were roughed off at the ends to provide handles. The canvas cover was a one-piece fabric, 5 feet 11 inches long, and was attached to the side poles by a large number of 6-ounce tacks. Lateral folding of the litter was made possible by the use of two pieces of wrought iron which were fastened to the under side of the assembly at each end of the canvas, and were hinged in the center. These two sets of braces were fastened to the poles with heavy screws, with pieces of common hoop iron underneath them to protect the wood. The feet or legs of the litter consisted of ordinary white ash sticks, 14-1/2 inches long, which were attached to the side poles with screw bolts riveted through the upper end to prevent splitting. The stick supports were set diagonally, facing outward toward the pole ends.

The outstanding contribution of the Halstead design to future litter development was the introduction of the hinged brace, a precursor of our modern spreader bar. In place of the rigid wooden cross bars of the Satterlee model which fitted between the side poles and were level with the top surface of the litter, folding metal bars inserted beneath the canvas cover were now substituted. The creation of this primitive type of spreader bar necessitated a related change in the feet or legs of the litter, but in this instance the improvisation was less successful. The slanting stick supports disappeared from litter specifications after 1892.

Taken all in all, the number of basic changes in Army litter construction which were introduced in the Halstead design was remarkable. Over-all weight and width of the litter were reduced, side poles were shortened, handles began to emerge as an individual component, hinged metal braces replaced the rigid cross bars of the Satterlee model, one-piece canvas was substituted for the two-piece cover, and tacking superseded the use of hem loops as the means of attaching the litter cover to the poles. All of these modifications, with the exception of the last, established directions and trends in litter design which have continued down to the present day. The substitution of tacked-on canvas for the Satterlee hem arrangement, though destined to be preserved in litter specifications for the next 70 years, was finally discarded in 1934 and has not been reverted to since that time.

3. The Medical Board Litter (1892).



Few modifications were made in the Halstead litter until 1891, when a board of medical officers was

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convened in New York City to examine and improve the means of transportation of the sick and wounded. The litter which this board developed was adopted as standard the following year. The side poles were 7 feet 7-1/2 inches long, were square in shape, and were rounded for 9 inches at the ends to form handles. The tacked-on cover was a one-piece linen duck, 7 feet in length. The feet of the litter consisted of four metal stirrups made of steel or wrought iron. Each stirrup was formed by two metal strips which were first crossed and welded at the intersection, after which the opposite ends were brought together and welded, thus forming two loops. The smaller loop was squared to receive the side pole, while the larger loop constituted the stirrup. The transverse braces, each consisting of two pieces of steel or wrought iron, were joined as before in the center, but with a somewhat improved hinge arrangement.

The most significant contribution of this new design was the invention of metal stirrups to replace the slanting wood legs of the Halstead litter. The idea had been perhaps hinted at in the large unclosed bar loops of the Satterlee model, but now for the first time the definite stirrup shape was visualized and developed. This innovation was to have a lasting effect on subsequent litter construction. Aside from this one feature, the Medical Board litter represented in the main a logical continuation of the trends which had been established in 1861. Litter bulk was further reduced, poles were shortened, handles were more carefully rounded, the hinged braces were improved slightly and strengthened. The linen duck cover, which had been slightly increased in length in the Halstead model, was now further lengthened by a full 13 inches. Tacking continued to replace hem loops for fastening the cover to the side poles.

Specifications for this litter were later modified in only one particular. Shortly before the Spanish-American War, wrought iron was made mandatory for the stirrups and braces, the latter being tinned or galvanized to prevent rust and attached to the bottom of the side poles with heavy screws.

4. The Ash Pole Litter (1916).

The 1916 litter (see Fig. 4) weighed 22 pounds and was 22 inches wide. Its side poles were constructed of straight grained ash, were 7 feet 6 inches in length, were rectangular in shape, and the ends were rounded off for 9 inches to form handles. The one-piece canvas cover was 6 feet 2 inches long and was tacked to the upper surface of the poles which were shaved away so that the top surface of the cover was flush with the unshaved portions of the poles.

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The braces, or spreader bars, were of cast iron construction and were so designed that, when closed, they extended lengthwise toward the center of the litter immediately between the two side poles. The cast iron stirrups consisted of one metal loop and an attached metal plate which was belted to the pole. The litter was so constructed that it was able to support a live weight of 200 pounds applied at the midpoint of each pole.

This litter, which was purchased during World War I, was unique in several respects. In the first place, the scale of the war with Germany had created an unprecedented demand for quantity litter production. Consequently, while the total production of Army litters during the entire four years of the Civil War had been only 50,000, between 15 May 1917 and 16 October 1918, approximately 375,000 of the new ash pole litters were purchased, and at a total cost of more than \$2,500,000.⁴ In the second place, the 1916 litter represented the culmination of a long, 56-year period of experimentation. It was by far the sturdiest and the most compact litter yet developed.

Probably the most outstanding feature of the new ash pole litter was its stirrup design. Instead of consisting of two metal loops, one of which encircled the pole, the stirrup proper was now a single metal loop which was secured to the pole by a flat metal plate. This facilitated mass production of the item, reduced the cost, and constituted on the whole a much more serviceable support for the loaded litter. In other respects the 1916 litter represented, like the Medical Board litter of 1892, a continuation of trends already established. Weight was decreased, poles were again shortened, handles remained unchanged, the canvas cover was shortened but was otherwise unchanged, spreader bar hinges were improved, and cast iron was substituted for wrought iron in the complete undercarriage assembly.

There was only one subsequent alteration of design of the ash pole litter and that one was minor in nature. In 1917, the location of the spreader bars was changed from 24 inches to 17 inches from the ends of the poles to adapt the litter to the fittings on the wheeled litter carrier which was then being purchased in France.⁵

5. Conclusion.

Examination of the comparative data regarding the straight pole litters which have been used by the United States Army from 1860 to 1918 may serve to clarify and emphasize the various major trends in litter construction and design which have been referred to at various points in the preceding discussion.⁶

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a. Litter weight and width.

Litter weight was reduced steadily throughout the 58-year period, but the total decrease in weight from 1860 to 1918 was very slight, amounting to only 2-1/2 pounds. Width was also reduced with each successive model, totalling a 5 inch decrease for the entire period.

b. Side poles and handles.

While the construction of the side poles differed only with respect to the type of ash wood employed, important modifications were made in other characteristics. Pole length was decreased drastically from 8 feet 9 inches in 1860 to 7 feet 6 inches in 1916. Pole shape changed frequently, but according to no apparent pattern, while pole thickness was increased slightly during the period. Handle formation was developed from a crude roughing off at the pole ends to a careful rounding, but the handle had not yet emerged as an entirely separate component.

c. Litter cover.

Except for a single instance where linen duck was used, canvas was the material of choice for the litter cover. The 1860 design, which specified two-piece canvas sewed at the center, was abandoned in all subsequent models which employed simply a one-piece fabric. Generally speaking, the length of the cover was increased somewhat, although the 1892 specification of 7 feet was considered excessive and was reduced by 10 inches in the ash pole litter. Although, in the 1860 model, the canvas cover was attached to the side poles by passing the poles through hem loops in the canvas, this method was not followed in any of the succeeding litters. Instead a tacking arrangement was substituted. It may be observed parenthetically that future litter designs were to return to the hem loop method as being the most practicable for military use, especially with round poles. With the elimination of the cross bars of the Satterlee litter, no end attachments were necessary, so the lacing device appeared only in the 1860 model.

d. Stirrups and spreader bars.

The greatest number of changes occurred in undercarriage design. The material used in the construction of the feet or stirrups varied widely, but indicated in general a preference for metal (iron) as against wood. Steel appeared as an optional material in 1892, but was subsequently

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TABLE I

COMPARATIVE LITTER DATA (1860-1919)

Explanation of Symbols.

- I. The Satterlee Litter (1860)
 II. The Halstead Litter (c. 1861)
 III. The Medical Board Litter (1892)
 IV. The Ash Pole Litter (1916)

1. Litter Weight and Width.

I.	24.50 lbs.	27.00 in.
II.	23.75 lbs.	23.50 in.
III.	Not given	22.00 in.
IV.	22.00 lbs.	22.00 in.

2. Side Poles.

	Construction	Length	Shape and Thickness	Handles
I.	Seasoned red ash	8' 9.0"	1.50" in diameter; circular	Round; no tapering at pole ends
II.	Seasoned white ash	8' 0.0"	1.83" square	Roughed off at pole ends
III.	Not given	7' 7.5"	2.00" square	Rounded for 9" at pole ends
IV.	Straight-grained ash	7' 6.0"	2.00' x 1.50"; rectangular	Rounded for 9" at pole ends

3. Litter Cover.

	Construction	Length	Side Attachment	End Attachment
I.	2-piece canvas	5' 10"	Hem loops	Laced to cross bars
II.	1-piece canvas	5' 11"	Tacks	None
III.	1-piece linen duck	7' 0"	Tacks	None
IV.	1-piece canvas	6' 2"	Tacks	None

4. Undercarriage.

Stirrups		Spreader bars	
Construction	Shape	Construction	Shape
I. Wrought iron	Unclosed loops	White oak	Rigid cross bars
II. White ash	Slanting sticks	Wrought iron	Hinged braces
III. *Wrought iron	Two closed loops	*Wrought iron	Hinged braces
IV. Cast iron	One closed loop and pole plate	Cast iron	Hinged braces

*Initially steel or wrought iron; later wrought iron specified exclusively.

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discarded for wrought iron. The shape of the feet, however, aside from the one departure presented by the slanting stick arrangement of the Halstead litter, underwent a highly logical cycle of development. From the crudely curved iron bar of the Satterlee litter, with its large unclosed loops raising the body of the litter nearly 12 inches off the ground, the 1892 design progressed to a much smaller, closed, double-loop device. The evolution was culminated in the trim single-loop stirrup and pole plate of the ash pole litter, which elevated the canvas surface only 4 inches above the ground.

In the 1860 litter, with its rigid cross bars holding the poles apart, lateral folding of the litter was impossible without fairly complete disassembly. The factor of lateral collapsibility, however, was attained in the Halstead model of the following year by the introduction of crudely hinged wrought iron braces. Thereafter, it was a relatively simple operation to bring the poles of the litter together and tie them, thus reducing both size and bulk and affording much easier handling and stacking. In later models improvement was made in the hinge mechanism and, in the 1916 design, cast iron replaced wrought iron in the spreader bar construction.

B. The Period from 1918-1941.

Compared with its predecessors, the 1916 ash pole litter was manifestly a great improvement. It had stood up well in the war and, while some maintenance difficulties were experienced, the litter had been procured in sufficient quantity to insure adequate replacement of the complete item if necessary. Consequently, with the advent of peace and the subsequent sharp reduction of public expenditure for the military establishment, litter research activities in the Medical Department were continued on a much more limited scale and at a greatly relaxed tempo.

On 26 February 1925, for example, the Chief of the Organization Division of The Surgeon General's Office wrote as follows to the Commandant, Medical Field Service School, Carlisle Barracks, Pennsylvania.

In the Equipment Laboratory please list for investigation and possible experimentation in the future the item of "Litters" now used in the service. Our standard litter seems to be fairly satisfactory but perhaps it can be improved by reducing its weight, changing the type of stirrup, omitting litter straps, etc.

This is forwarded merely as food for thought. There is no urgent need for a change at this time.⁷

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Throughout the 'twenties, as is abundantly indicated in the official correspondence that passed during this period, the attitude of the Medical Department was largely one of satisfaction with the ash pole litter as the ideal litter for general military use. Typical of this viewpoint was the following appraisal written in 1927 by General (then Major) Roy C. Heflebower:

It [the ash pole litter] combines all the best principles of the multitude of litters which have preceded it both in our own country and abroad. It is light, compact, comfortable, rigid, durable and easily carried, whether by hand, by ambulance, litter carrier or other type of conveyance.⁸

Nevertheless, just four years after the above statement was written, development was begun on a new and revolutionary type of straight pole litter which was destined to surpass in virtually every respect the ash pole litter of World War I.

1. The Standard Aluminum Litter (1935):

In 1931 the Medical Department roused itself from its long period of research inactivity in the litter field to investigate the possibilities of aluminum as a substitute for the straight grain ash poles and cast iron undercarriage of the 1916 litter. After much experimentation, both independently and in collaboration with private industry, early in 1932 the Medical Department Equipment Laboratory brought forth a new and promising pilot model, equipped with duraluminum tubing and cast aluminum running gear. A number of the new litters were soon sent to field units for test and report and, aside from minor objections regarding hand grips and spreader bar design, the reaction was extremely favorable. Before the close of 1934, all indicated changes had been made. Detachable hard wood handles had been provided, and spreader bars had been redesigned with a greater downward curving to insure a maximum of patient protection. With the completion of this construction work, in the spring of 1935 sixty-nine of the modified litters were manufactured and distributed to outlying Army stations for service testing. The reports subsequently received gave every indication that the new litter would prove to be the best that the Medical Department had yet produced.⁹

The new standard aluminum pole litter (see Fig. 5) was indeed a streamlined invention. It weighed only 15-1/2 pounds. Its poles were of aluminum tubing, 1.54 inches outside diameter, 0.109 inch wall thickness, and 77 inches long. The litter handles were separate components of wood construction, 9-1/2 inches long, and projected 6-1/2 inches

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from the pole ends. The stirrups and spreader bars were of cast aluminum and weighed 4.56 pounds per litter. Holding the stirrups to the poles were cadmium plated steel bolts with heads which were oval-shaped to fit the pole and canvas. The canvas cover was attached to the side poles by a hem arrangement not dissimilar to the one employed in the Satterlee litter. The cover was secured to the poles at each end by a single bolt.¹⁰

With the development of the aluminum litter, the old ash pole litter of World War I suddenly seemed almost anachronistic. The Medical Department Equipment Laboratory summarized its comparative findings as follows:

The weight of this litter [1916 model] presents its most serious objections. Other objectives are: the handles are more often broken than any other part of the litter; when the canvas splits, 142 tacks have to be removed and replaced. If a handle is broken, 9 screws, 2 rings, 2 studs and 71 tacks all have to be removed and replaced, if and when the litter is salvaged.

In the round pole [aluminum] litter (weighing 15-1/2 pounds) if the canvas splits, only 4 bolts need be removed and replaced. If one pole is broken only two bolts are removed. If a handle breaks, it can be replaced by another, very easily.¹¹

The new aluminum pole litter incorporated the best features of all the litters which had preceded it. In the circular shape of the poles and the use of hem loops instead of tacks for attaching the canvas cover, the new design bore considerable resemblance to the Satterlee litter. The stirrup arrangement, on the other hand, constituted simply a natural culmination of a long trend of development. The 1916 litter had substituted a metal plate for the squared wrought iron loop of the 1892 model as a means of securing the stirrup to the side pole. Now this metal plate was in turn superseded by a small oval-headed bolt which was shaped to fit the curvature of the poles.

The new design, however, introduced several radical departures from conventional litter construction of the past. The most notable innovations, perhaps, were the substitution of aluminum for iron in the undercarriage, and the use of metal tubing in place of solid ash wood for the side poles. These two improvements alone resulted in a weight reduction of 6-1/2 pounds, a formidable accomplishment in view of the fact that from 1860 to 1935 over-all litter weight had been decreased by only 2-1/2 pounds.

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Only slightly less significant was the emergence of the litter handle as a separate component; as an insert rather than an integral part of the side pole. This not only permitted a reduction in pole length to 77 inches with a corresponding decrease in weight, but it served to eliminate one of the most troublesome and costly problems of field maintenance. Handle breakage, a frequent cause of failure of the ash pole litter, no longer necessitated complete replacement of the side pole. From this time forward it involved merely a replacement of inserts.

All in all, the new aluminum straight pole litter was an outstanding achievement. The ash pole litter of World War I had been clearly surpassed, and before the close of 1941 procurement of that item was discontinued completely.¹² Furthermore, the structural features and design of the new litter were to exert a profound influence on subsequent development activities. In the search for aluminum substitutes, the period which is next to be considered, the standard aluminum litter was explicitly adopted as a model to be approximated as closely as possible.¹³

2. The Aluminum Shortage.

The straight aluminum litter was duly standardized, assigned an item number of 9935000 in the Medical Supply Catalog, and procurement was initiated. However, as early as April, 1941, the Medical Department was required to justify before the Office of Production Management the production of aluminum litters then going forward.¹⁴ The ancient danger of a critical shortage was beginning to show itself.

Before the close of 1941, the tremendously increased United States aircraft program had made it imperative that aluminum, especially of aircraft grades, be sharply curtailed or eliminated from the production programs in other fields. On 12 January 1942, a comprehensive directive, calling for drastic reduction in the use of aluminum, was issued by the War Department.¹⁵ By Memorandum from the Office of the Under-Secretary of War to The Surgeon General, dated 3 March 1942, the general policy of aluminum conservation was applied specifically to the "Field Litter", making the elimination of the aluminum specifications for this item mandatory.

It is only with these facts clearly in mind that the psychological as well as the material difficulties confronting Medical Department research and development can be properly appreciated. Staff planners and coordinators, research engineers, specification writers, and procurement officers were to have just eleven months to solve in all its complex phases a problem of the most crucial importance to

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the entire process of medical evacuation. In less than a year a new standard litter, as yet undesignated, had to be moving from the assembly lines into Army supply depots. How well the Medical Department discharged that obligation may be judged from the account that follows.

II. Initiation of Development Project, F-11.

In 1941, the Army Regulations which governed administrative procedure for the initiation of development projects required: (1) formulation and approval of military characteristics by the using Arm or Service; (2) coordination through the Technical Committee of the Service charged with development and procurement of the item; (3) preparation of a development program by the appropriate Service; (4) forwarding of this project data by the Technical Service concerned to The Adjutant General for final approval by the Secretary of War.¹⁶

To what extent was this prescribed procedure followed in initiating the project under discussion?

A. Formulation of Military Characteristics.

Extensive examination of the available source material discloses three documents of a primary nature relating to this and other procedural steps. The first, a report entitled, Medical Department Research Program, Fiscal Year 1941, was submitted to The Adjutant General on 3 April 1941 by The Surgeon General's Office. This document contains the following statement with regard to military characteristics:

Military Characteristics.

- (1) To provide for procurement of suitable substitute materials to replace materials now used in manufacture of the standard litter, in the event the latter materials become unobtainable in war time.¹⁷

Since what was here being proposed was simply a possible change in materials and not in basic design of the standard litter, it would appear that the foregoing was an adequate statement of military characteristics within the meaning of AR 850-25. That regulation stated:

The term "military characteristics" is used to denote the characteristics of any type or article of equipment that have a definite bearing on its tactical use.¹⁸

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B. Coordination of Proposal through Technical Committee.

It does not appear that Development Project, F-11 was cleared through the Medical Department Technical Committee, which agency represented the Service (the Medical Department) which was to be charged with the development and procurement of the new item. Recorded evidence was found of only two meetings of this committee during the period in question: one on 28 November 1940, and a second on 17 March 1941. The published minutes of these meetings contain no reference to the project under discussion.¹⁹

C. Preparation of a Development Program by the Appropriate Service.

The report, Medical Department Research Program, Fiscal Year 1941 contains a brief description of the development program which was to be undertaken in connection with the subject project. While this statement was neither as precise nor as comprehensive as some of the program outlines which were to be submitted in later years, it nevertheless represented a sufficient compliance with Army Regulations.

It is hoped to obtain some steel and iron litter poles this fall so that litters can be made and poles tested in the field. The Equipment Laboratory feels that many materials such as plastic, round wood, and steel might all be experimented with as well as many other materials for poles, stirrups, and spreader bars.²⁰

D. Clearance of Project Proposal with Higher Authority.

Compliance with this last procedural step required by Army Regulations for project initiation is clearly indicated. On 3 April 1941, the initiation request was prepared in final form and submitted to The Adjutant General.²¹ On 9 April 1941, formal approval of the proposed research program was obtained from the Secretary of War.²²

E. Conclusion.

In conclusion it may be stated that: (1) a set of military characteristics were prepared by the Medical Department which can be considered adequate within the meaning of AR 850-25; (2) a satisfactory general outline of the proposed development program was formulated by The Surgeon General's Office; and (3) the final project proposal was submitted through the correct channels and was properly approved.

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Apparently, however, Development Project, F-11 was not processed as required through the Medical Department Technical Committee.

This latter omission, although it did represent a lost opportunity for formal consultation and coordination with other interested Arms and Services, did not in the present instance have serious consequences. There were, perhaps, several reasons for this. In the first place, although changes in battle tactics had occurred, these had not altered materially the role of the straight pole litter in the evacuation process. Secondly, since a continuing need for the standard litter was beyond question, it was perfectly clear that a firm military requirement for a new litter development project existed. The alarming scarcity of aluminum, as pointed out in the Medical Department report, was sufficient reason in itself.

Aluminum is now a critical item and it is anticipated that aluminum pole orders will be greatly delayed so that this type of litter may be almost unprocurable. It is, therefore, highly desirable to find suitable and as light as possible substitutes.²³

Finally, it will be seen that the straight steel litter, as eventually developed, was sufficiently similar to the 1935 standard aluminum pole litter that no new difficulties were experienced in adapting it to the various types of land transportation.

III. Development Phase (1) (The Steel Litter).

A. Preliminary Stage.

Project F-11, "Development of New Materials for Standard Litters," (title subsequently changed to "Litter, Standard, New Materials For"), was formally initiated 9 April 1941. Fortunately, laboratory activities had been begun much earlier, having been undertaken on an informal basis since September of the preceding year.²⁴ Consequently, by the middle of July, 1941, the Medical Department Equipment Laboratory had already subjected nine newly developed litters to engineering and service tests, and the knowledge gained from this preliminary experimentation did much to guide and focus the research activities that were to follow.

Foreign litters were carefully investigated at the outset. Through the cooperation of the American Red Cross, a Czechoslovakian litter was forwarded to Carlisle Barracks

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early in the fall of 1939.²⁵ Extensive correspondence was carried on with the American Embassy in London with regard to the British litter and, before the outbreak of war between the United States and the Axis powers, our Military Attaché in Berlin secured a German litter which was subsequently shipped to the Experimental Laboratory Museum at Carlisle.²⁶ Furthermore, in May of 1941, through the efforts of the United States Military Attaché at Ottawa, a Canadian all-metal litter was sent to The Surgeon General's Office for examination and study.²⁷ In addition, through correspondence, descriptive literature, blueprints, and photographs, information was obtained about a number of other foreign litters, notably the Swiss and Austrian.²⁸

As a result of its own past experience, the Medical Department Equipment Laboratory was, of course, fully aware of the many variables that would have to be carefully considered in the development program that was about to be undertaken. Recalling the introductory comments in Chapter I, it will be readily seen that these numerous requirements narrowed substantially the possible scope of the investigation.

In searching for substitutes for the standard litter, the following have been given consideration:

- a. Is the material available?
- b. Can it be obtained in quantity?
- c. Is it durable and sufficiently rugged for field service?
- d. Weight of all materials; what weight will the completed litter be? Can it be made with the minimum weight?
- e. Can the litter be made simple, yet strong and foolproof? Can it be made so that repairs can be made readily anywhere?
- f. Will the poles produce excess whip; or will they be too rigid?
- g. Standard in size; length and width? Height from the ground?
- h. Suitable handles for the litter bearers?²⁹

Inasmuch as the standard aluminum pole litter was considered by far the best in terms of weight, ruggedness, flexibility, and ease of maintenance, it was taken as the working model.³⁰ It was also believed that a round pole litter would be better than a square or rectangular one. Round poles produced less wear on the canvas and facilitated repairs and maintenance, since the poles could be easily removed from the bolted hem loops of the cover.³¹

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This, then, was the background against which the search for aluminum substitutes was to proceed. There were 80 years of litter research experience to draw from, contemporary foreign litters had been extensively studied, and the complex engineering requirements for militarily satisfactory litter construction had been carefully outlined in advance. There now remained the enormously difficult job of speedily developing a single physical model which would meet all specifications.

B. Republic Steel Corporation, Steel & Tube Division;
Cleveland, Ohio.

By September, 1940, correspondence had already been initiated between the Medical Department Equipment Laboratory and the Steel & Tube Division of Republic Steel Corporation, Cleveland, Ohio, relative to the possibility of substituting steel tubing for aluminum.³² Before the close of the year, a sample shipment of four sets of litter poles, two of stainless steel and two of cold rolled steel, were received by the Laboratory.³³

The four sets of steel poles which were submitted for testing were as follows: (1) Enduro, 20 gauge, 1-1/2 inches in diameter, unannealed; weight of litter complete, 16 pounds; (2) Enduro, 18 gauge, 1-1/2 inches in diameter, unannealed; weight of litter, 18 pounds; (3) Cold rolled, 20 gauge, 1-1/2 inches in diameter; weight of litter, 15 pounds; (4) Cold rolled, 18 gauge, 1-1/2 inches in diameter; weight of litter, 17-1/2 pounds.

Upon receipt, these poles were forthwith inserted into the framework of the standard straight pole litter with its regulation canvas and cast aluminum running gear, and were forwarded to the 32nd Medical Battalion, Carlisle Barracks, Pennsylvania for field testing. The following instructions were given by the Laboratory:

Testing: It is requested that these four litters be comparatively tested with litters having other type poles, as follows:

- a. In ordinary litter work, are these steel poles sufficiently rigid for comfort of the patient?
- b. Do the poles bend excessively with heavy patients?
- c. Do the poles bend excessively when carrying a heavy Medical Department chest?
- d. Do the poles set in a bent position after carrying a heavy patient for a considerable distance? A heavy M.D. chest or such other Medical Department equipment that might be carried on a litter in the field? ³⁴

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Three separate tests were performed by the 32nd Medical Battalion. In the first test the litters were subjected to ordinary patient carries over normal terrain. Poles 2 and 4 were sufficiently free of swing and the patient was comfortable, while poles 1 and 3 bounced to such an extent that the patient immediately noticed the whipping motion, and the litter bearers felt an appreciable increase in the weight of the load.

In the second test the litters were placed with their stirrups on the floor of a truck, and patients of approximately the same weight were placed on each litter. Poles 1 and 3 whipped up and down somewhat during the trip and, at the completion of 40 miles, were found to have bent and set. The two heavier poles had not whipped noticeably during the trip, and were straight at the termination.

In the final test, each litter was suspended between two empty Medical Department chests. A Medical Department chest, weighing 150 pounds, was then placed on each litter, removed, and replaced. This operation was repeated twenty times for each litter. Poles 1 and 3 again bent and set noticeably after several applications, as did pole 4. Pole 2 sagged slightly after the twentieth application. The standard aluminum pole litter, by way of contrast, retained perfect alignment throughout the test.³⁵

In view of the foregoing results none of the steel poles could be recommended for Medical Department use, but the lessons which had been learned in this initial experiment were extremely valuable. In a letter to the manufacturer of the steel tubes, the Director of the Laboratory summed up the field test findings and their significance as follows:

Service test using litters fabricated from these poles indicated that all steel tubes tested would take a permanent set after a short period of use. Also, due to the low section modulus of the steel poles, an undesirable whipping action was encountered in carrying patients on the litter.

As a result of these tests, it was established that steel poles would not be a satisfactory substitute for aluminum poles without appreciable increase in weight.³⁶

C. Medical Department Equipment Laboratory; Carlisle Barracks, Pennsylvania.

Having completed its preliminary canvass of steel possibilities, the Laboratory next turned its attention to

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wooden poles as a substitute for aluminum. In its own workshop at Carlisle Barracks, Pennsylvania the Laboratory constructed two sets of round ash poles of differing diameters and then made each of these sets into a litter, using the standard cast aluminum spreader bar assemblies and stirrups, and the regulation canvas. The two experimental litters are described as follows: (1) straight grain ash poles, 1-3/4 inches in diameter; litter weight, 15-1/2 pounds; (2) straight grain ash poles, 1-1/2 inches in diameter; litter weight, 13-3/4 pounds.³⁷

The litters were apparently subjected to only one field test, an ordinary casualty carry. According to the Laboratory report, the 1-1/2 inch poles developed a decided whipping action in transporting a patient, while the 1-3/4 inch poles proved sufficiently resilient and had but little whip. However, the diameter of the latter pole was considered too large to be suitable, and plans were made to construct two new sets of poles with a diameter of 1-5/8 inches.³⁸ Details are lacking regarding the date of completion of these new side poles, or of the specific tests to which they were subsequently subjected. On 3 January 1942, however, the Medical Department Equipment Laboratory reported that ash poles, 1-5/8 inches in diameter, had been previously tested and had been found unsatisfactory.³⁹

While the field test data cited above does not appear to be altogether conclusive, the unsuitability of solid wooden poles for Medical Department use was definitely established by the next series of tests which were performed on experimental models submitted by the Zimmer Splint Company. Moreover, further experimentation in this field was soon to be abandoned for additional reasons. Information was shortly to be received by the Laboratory indicating that it was extremely unlikely that straight grain ash poles would be available to the Medical Department in the quantities necessary.⁴⁰

D. Zimmer Splint Company; New York, New York.

In June, 1941, three wooden pole litters were received by the Laboratory from the Zimmer Splint Company of New York City. Two of these litters had round wooden poles, 1-1/2 inches in diameter. The third had square poles, 1-5/8 by 1-5/8 inches, the canvas cover being held on by means of a strip of aluminum, 71 inches in length, which was held to the under surface of the poles by 9 screws.⁴¹ Thinking back to the ash pole litter of World War I with its 142 tacks to secure the canvas, this new device was an interesting modification. It was still, however, clearly inferior from a repair and maintenance standpoint to the convenient slip-on cover of the standard aluminum litter.

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The most significant feature of the new litters, although it contributed nothing toward the solution of the immediate problem at hand, was the undercarriage with which each litter was equipped. Both the stirrups and spreader bars had been fabricated of extruded instead of cast aluminum. According to the Laboratory, these extruded parts were found to possess the following advantages over the standard cast aluminum undercarriage:

- a. Lower cost of manufacture.
- b. More rapid procurement, as all parts are formed from extruded bars. The present standard litter is composed of several aluminum castings. At the present time extrusions can be obtained much more quickly than castings.
- c. Greater durability, in so far as breakage of parts is concerned, as the extruded parts have a greater resistance to shock loading than castings.⁴²

Using extruded aluminum, the weight of a complete stirrup and spreader bar assembly was 2.08 pounds per litter. This represented a reduction in weight over the standard cast aluminum undercarriage of 0.40 pounds per litter. Any weight reduction, however slight, which involved no loss in other qualities such as durability, could be regarded as a genuine gain.

The change from cast to extruded aluminum in Medical Department litter specifications was effected without delay and resulted, until the production of aluminum litters was prohibited in March, 1942, in more rapid procurement of a greatly improved straight pole litter.⁴³ Viewed historically, this innovation was of real significance as it represented another one of the major steps in litter evolution.

As for the experimental wood poles of the Zimmer litter, the following test instructions were issued by the Laboratory to the 32nd Medical Battalion:

Carries up to 1/2 mile loaded with patient weighing 175 pounds or more. Particular attention should be given to the whip of the poles if this is excessive.

Loading and unloading from ambulances and cargo trucks to determine the effect of shock and weight on the stirrup assembly and on the wood poles.

Would you recommend that wooden poles (straight grain ash) be adopted to replace the present

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aluminum poles, and, if so, is the square or the round pole recommended?⁴⁴

The test results this time left no doubt as to the unsuitability of solid wooden poles as a substitute for aluminum. While all three litters satisfactorily withstood the shock and weight of loading and unloading from ambulances and cargo trucks, the patient carry produced markedly unfavorable results. The whip of the poles in all three litters was so excessive that it was believed that an actual casualty would have been subject to further injury from shock as well as the danger of literally falling off the litter. One round pole broke under the whip that was produced, while the second set of round poles exhibited a bow of 2 inches and 3-3/4 inches, respectively. In the litter equipped with square poles, bows of 1 inch and 1-3/8 inches, respectively, were recorded.⁴⁵

The 32nd Medical Battalion consequently recommended that the straight grain ash poles be rejected as a replacement for the standard aluminum poles, and this report was subsequently concurred in, without reservation, by the Medical Department Equipment Laboratory.⁴⁶ Evidently the search for aluminum substitutes had been rewarding thus far only in the elimination of certain construction materials from further consideration.

Small dimension stainless and cold rolled steel had now been tested. Both round and square straight grain ash poles of varying dimensions had also been subjected to complete engineering and service tests. In each instance the results had been negative. Furthermore, a number of other substances had been investigated, but as yet no tangible evidence of their utility had been found.

Numerous firms and their representatives have been contacted re substitutes; but so far the search may be considered still unsettled. So far, no manufacturer of plastic or hard rubber has been able to produce a satisfactory substitute for the metal parts of the litter, regardless of many claims by individuals. It is possible that poles of an alloy steel with pressed steel spreader-bar assemblies, may have to be resorted to, if and when aluminum is not available.⁴⁷

E. Revere Products Corporation; Phoenix, New York.

The idea of using pressed steel for the litter undercarriage, as mentioned above, had already been

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incorporated in an actual model submitted to the Laboratory by Revere Products Corporation of Phoenix, New York. The pair of pressed steel stirrups and spreader bars which this concern had produced were considered both sturdy and well-designed, and weighed 2.82 pounds per assembly, or 5.64 per litter. This latter figure may be compared with the 10.00 pound litter weight of the new extruded aluminum, and the 4.16 pound weight of the new extruded aluminum undercarriage.⁴⁸

The Revere assembly, however, had been designed for the old rectangular litter pole. Since only the round pole was now being considered, redesigning of the assembly was necessary before field testing could be initiated. Consequently the Equipment Laboratory, working directly from the Revere design, prepared a new set of drawings and specifications, adapting the pressed steel undercarriage to the standard round pole litter.⁴⁹ Final blueprints were then forwarded to Revere Products Corporation for fabrication of several actual assemblies.⁵⁰

It is not clear, from the data at hand, whether the Laboratory ever received delivery of these pressed steel assemblies. There is no record of a separate field test being made of the modified Revere undercarriage. However, the essential features of the original Revere design were incorporated into subsequent litter models and, although the basic design underwent substantial modification as a result of field trials, this initial idea was a contribution of genuine value.

F. Zimmer Splint Company; New York, New York.

As we have seen, it was no longer certain that straight grain ash wood could be procured in sufficient quantity for Medical Department needs. The sudden appearance of another critical shortage now narrowed research possibilities still further. Alloy steel, the Laboratory was now informed, was rapidly becoming as strategic as aluminum.⁵¹ To surmount this difficulty, carbon or rail steel was next resorted to. In September, 1941, the first litter to be constructed of this new material was submitted by the Zimmer Splint Company of New York City. The new model was also equipped with a pressed steel undercarriage.

The poles were formed from 0.45 per cent carbon steel, and were 1-1/4 inches outside diameter, with a 15 BW gauge wall. This size tubing was found to have approximately the same strength as the 1.54 inch aluminum pole with a 0.109 inch wall. The use of 1-1/4 inch outside diameter steel poles had been necessary since such high carbon tubing could not be rolled with any smaller wall thickness. Conversely it was felt that 1-1/2 inch poles would be stronger

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than necessary and would add considerably to the weight of the litter. The undercarriage of the new litter was constructed of pressed steel, while the wooden litter handles were circular and grooved.⁵²

The standard instructions were given to the 32nd Medical Battalion regarding testing procedures, with the additional stipulation that the stirrup and spreader bar assembly be thoroughly tested in mud and sand to determine the effect on the hinges and stirrup bearings. As in the past, the experimental litter was to be tested in direct comparison with the standard aluminum model.

Hand carries up to 1/2 mile were made with a patient load of more than 175 pounds, and the litter was loaded and unloaded from ambulance and cargo truck. It was determined that the steel tube poles had approximately a 1/4 inch whip, slightly more than the negligible whip of the aluminum pole but not sufficient to be harmful. The poles exhibited no discernible bow or set. On the other hand, the stirrups cut and scarred the floor of the ambulance and truck, the spreader bars tended to collapse when in use, and the circular grooved handles produced blisters on the hands of some of the bearers even in short carries.

In conclusion, the 32nd Medical Battalion recommended that the small diameter carbon poles be adopted to replace the standard aluminum poles, that the grooved handles be redesigned, and that the undercarriage be rejected as not rugged enough for field use. Significantly, for the first time, the testing agency submitted a list of suggestions, four in number, by which the mechanical defects noted might be overcome. This, it is evident, gave the manufacturer something concrete to work on, and undoubtedly shortened the time required for experimentation.⁵³

In less than two weeks, three new experimental litters were submitted by the Zimmer Splint Company. Since the side poles of the first Zimmer litter had been found to be satisfactory, this component was unchanged in the new models. The heavily ridged hand grips of the earlier model had, however, been eliminated in favor of the smoother wooden handle inserts of the regulation aluminum litter. In addition, undercarriage construction had been materially altered. Each of the three experimental models now submitted represented a slightly different application of an entirely new basic design.

The tests conducted by the 32nd Medical Battalion were the most severe to date, as can be seen

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from the following enumeration:

1. The three steel pole litters were tested in comparison with the present standard aluminum pole litter.
2. Numerous carries up to 1/2 mile on each of the litters, loaded with patients weighing 175, 185, and 200 pounds, were made.
3. Loading and unloading patients from ambulances was practiced. Cargo trucks of 1/2 Ton and 1-1/2 Ton were loaded. Both wooden sides and seats, as well as the floor, were used as the supports of loaded litters. The latter were loaded to a capacity load of ten litters per 1-1/2 Ton truck, and four litters per 1/2 Ton pickup truck. Cross-country drives over extremely rough terrain were made with all loaded vehicles.
4. A thorough testing in six inches of mud in the stream of Letort Spring Run, with open and closed litters, was made to determine the effect of mud upon the stirrup bearings and hinges. The effect of the mud was noted upon the bearings both immediately, and after drying for twenty-four hours. The litters were then cleaned and dried. The effect of commercial building sand upon the stirrup bearings and hinges was tested.
5. One end, including the handles and spreader bar assembly, of each of litters Number 2 and 3 was submerged in water twenty-four hours to determine the effect of water upon the plain and varnished handles.
6. Numerous carries of Number 1 Chest and Lanternsets were made.
7. Litters were handled roughly, in loading and unloading of empty litters in trucks and ambulances.⁵⁴

Test results again indicated that the poles were entirely satisfactory. It was observed, however, that on one litter which had each of its stirrup and spreader bar assemblies placed 3 inches closer to the center of the litter, the whip of the poles was cut to approximately one-half that of the other two litters. The spreader bars, during these tests, showed no tendency to bend or to collapse. However, in all instances, the bearing surfaces of the stirrups showed marked tendencies to weakness. Every stirrup bent at this same point in a moderate or severe degree, indicating far too much fragility for prolonged usage.

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The testing agency this time recommended the adoption not only of the steel poles to replace aluminum but also approved the new pressed steel spreader bars in place of the cast or extruded aluminum bars of the standard litter. Thus, only one component remained to be redesigned; the stirrups with their stirrup-spreader bar bearing. Once again technical suggestions for the improvement of this item were volunteered by the 32nd Medical Battalion.⁵⁵

Reviewing briefly the progress that had been made during September and October of 1941 with the Zimmer all-steel litter, it will be recalled that only the steel litter poles were found acceptable at the conclusion of the first series of service tests. The handles, the spreader bars, and the stirrups were all found to be defective but the testing agency, the 32nd Medical Battalion, offered specific recommendations for the improvement of these items. In the modified litter model which was presented early in October, the handle difficulty had been solved by simply duplicating the smoother handle of the standard aluminum litter. In addition, the spreader bars were strengthened and their hinge mechanism perfected, with the result that this component also was found to be satisfactory. This left for further modification only the stirrup assembly, which had again been rejected. For that task, technical advice was once more tendered by the testing authorities. In short, close coordination between Medical Department personnel and private industry appeared to be yielding gratifying results.

G. Superior Sleeprite Corporation; Chicago, Illinois.

In rather marked contrast to the highly efficient coordination of civilian and military effort referred to above, the story of the participation of Superior Sleeprite Corporation in this development program is, in the large, a story of willing but misspent effort. This misdirection can be attributed, at least in part, to a breakdown in communication between the Medical Department Equipment Laboratory and The Surgeon General's Office.

On 6 August 1941, two chrome-molybdenum steel litters were shipped by The Surgeon General's Office to Fort Benning, Georgia for service test by the Infantry School. One of these litters was made of 16 gauge tubing, had extruded aluminum stirrups and spreader bars, and weighed 20-1/2 pounds. The second litter was made of 18 gauge tubing, had standard cast aluminum running gear, and weighed 17-3/4 pounds. Both litters had been manufactured by the Superior Sleeprite Corporation of Chicago, Illinois.⁵⁶

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On 14 October 1941, the General Contracts Manager of Superior Sleeprite Corporation sent the following air mail, special delivery letter to The Surgeon General's Office:

Early last week I called upon Mr. Peters of the Revere Products Company, Phoenix, New York, and carefully covered the matter of the metal spreader arms for the litter.

I saw all the correspondence he had with Carlisle. It appears that Carlisle thinks enough of his ideas to make a drawing of their own, embodying all the features of his sample.

He has agreed to make another set of samples for me, which I, in turn, will forward to you, to be attached to the steel pole litter you now have at Fort Benning. This should be ready in about 10 days. If you will have the litters returned from Fort Benning to your office, where a pair of spreader bars can be attached to one of them, we will reimburse you for any transportation or other costs involved....

Mr. Peters tells me he can make only one pair of spreader arms, as these are very difficult to construct by hand. I presume the one litter should be sufficient for Carlisle's test....⁵⁷

It will be recalled that by 4 October 1941, the following had transpired at the Laboratory at Carlisle, Pennsylvania: (1) alloy steels, which were rapidly becoming as strategic as aluminum, had been definitely eliminated from consideration, (2) carbon steel poles had already been approved as satisfactory substitutes for aluminum, (3) experimentation with pressed steel undercarriages adapted from the original design of the Revere Products Company had reached an advanced stage; certain lessons had been learned; certain specific directions for further research had been outlined.⁵⁸

In other words the Superior Sleeprite Corporation was already virtually out of the picture. The poles of that company's litter were constructed of chrome-molybdenum, which was an alloy steel. Alloy steels were no longer being considered by the Laboratory at Carlisle because of their increasing scarcity. Furthermore, as a result of recent field tests at Carlisle, the modified Revere pressed steel undercarriage had already undergone considerable modification. Consequently, there was nothing to be gained by resubmitting a facsimile of the original undercarriage design. Unless, therefore, the Superior Sleeprite Corporation was put in immediate contact with the Laboratory, informed of the progress that had been made, and permitted to assist in solving the advanced developmental problems that remained, it is difficult to perceive how its efforts could be of value.

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The evidence at hand, however, does not indicate that such coordinating action was taken by The Surgeon General's Office. On 5 November 1941, approximately three weeks after receipt of the communication from the Superior Sleeprite Corporation, request was made of the Infantry School at Fort Benning for the return of one of the litters which had been forwarded in August for test.⁵⁹ Ten days later, on 15 November 1941, the litter arrived, and The Surgeon General's Office thereupon telegraphed the manufacturer, inquiring as to the status of the Revere assembly which was to be shipped to Washington.⁶⁰

By this time, however, a third Zimmer model had been submitted to the Laboratory at Carlisle, had been field tested by the 32nd Medical Battalion, and had been recommended by that agency for adoption as a satisfactory substitute for the standard aluminum pole litter.⁶¹ Seemingly unaware of this development, The Surgeon General's Office, after waiting several weeks for the pressed steel assembly to arrive, finally forwarded the Superior Sleeprite litter with its chrome-molybdenum poles and its cast aluminum undercarriage to the Medical Department Equipment Laboratory for formal test.⁶²

In a comprehensive test report, dated 3 January 1942, recommending the adoption of the new Zimmer all-steel litter, the Laboratory at Carlisle made the following comments with regard to the model supplied by the Superior Sleeprite Corporation:

Recently a litter made of chrome-molybdenum steel, aircraft tubing was received from The Surgeon General's Office for testing. Chrome-molybdenum steel as a substitute for aluminum was rejected by the Equipment Laboratory long ago for the following reasons:

- (1) All light weight alloy steels are as strategic as aluminum.
- (2) Their cost is exceedingly high, even compared to aluminum, averaging about 80 cents per foot for 1-1/2 inch by 20 gauge tubing; the cost of the poles alone would be over \$10.00 per litter.

The validity of the above statements is borne out by data received from the Superior Sleeprite Corporation, manufacturers of the chrome-molybdenum litters submitted by The Surgeon General's Office for test. This company states that delivery of chrome-molybdenum aircraft

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tubing will take from five to six months; no mention is made of quantities that could be supplied, but it is assumed that they would be very small in proportion to the quantities required for the mass production of litters.⁶³

No mention was made of the cast aluminum undercarriage of the Superior Sleeprite litter. As early as July, 1941, it will be recalled, extruded aluminum had replaced cast aluminum as the material of choice in the construction of stirrup and spreader bar assembly. By September, 1941, experimentation had begun on the pressed steel assembly which, by the time the above litter was received by the Laboratory, had already been perfected. Consequently, the undercarriage of the Superior Sleeprite litter had now been as definitely superseded as the chrome-molybdenum poles.

In this particular instance the damage caused by the lack of coordination between The Surgeon General's Office and the Medical Department Equipment Laboratory was slight. A private concern had sacrificed a modest amount of its time and money. The Medical Department had devoted a small portion of its facilities and personnel to continuing a predictably fruitless investigation. Towering above these considerations was the major fact that a successful substitute for the aluminum litter had been found, and within the required time. Whether, however, a similar lack of coordination between these two key agencies was to produce, in other situations, more serious and costly delays, it will be our purpose to investigate as we proceed.

H. Howe Folding Furniture, Incorporated; New York, New York.

On the very day when the first model of the Zimmer carbon steel litter was being forwarded to the 32nd Medical Battalion for test, Howe Folding Furniture, Incorporated wrote to The Surgeon General's Office to learn the requirements for the new straight pole litter which was under development.⁶⁴ The reply indicates not only the degree to which the standard aluminum litter was then being followed as a model, but illustrates once more the highly circumscribed character of wartime litter research.

In making up any model, it is requested that you remain exactly to the specifications of our aluminum pole litter, especially in the following points: Length of litter, width of canvas, outside diameter of litter poles, wooden handles, method of attaching canvas,

and general construction of the stirrup and spreader-bar assembly.

Weight should not be greater than 20 pounds, preferably less. As to the matter of angle or tube for litter side rail, I am unable to give you a definite answer. We naturally prefer tubing. However, if your design calls for an angle side rail, and it is a more efficient model than any we have, we are not bound by tradition to accept only tube. The decision in this matter is one which will rest solely with you, based on your design.⁶⁵

It is interesting to observe that the Zimmer model then undergoing test at Carlisle violated several of the above specifications. The poles were 1-1/4 inches outside diameter, instead of 1.54 inches as in the aluminum litter. Total litter weight was 22-3/4 pounds, as compared with the 20 pound limit cited above. Whether these restrictions were placed on Howe Folding Furniture, Incorporated for purposes of controlled experimentation, or whether they resulted from a lack of close understanding with Laboratory personnel at Carlisle, is not evident from the data.

On 31 October 1941, the same day that the third model of the Zimmer litter was submitted, a Howe all-steel litter was sent to the 32nd Medical Battalion by the Medical Department Equipment Laboratory for test.⁶⁶ The Howe litter, of course, closely paralleled the standard aluminum litter in many respects: length, width, and size of poles, type of handles, canvas covering, and method of folding. The weight of the litter was 17-1/2 pounds, and both tubing and spreader bars were made of pressed steel. The poles were of welded, mild steel tubing, 20 gauge, and were protected against rust, as were all other metal parts of the litter, by a coating of zinc, applied by the hot dip process. Rounded grooved maple handles were fitted into the ends of the tubing and held in place by crimping the end of the poles. The steel stirrups were fastened to the side poles by eight, instead of the usual four, oval headed bolts. The spreader assembly was made of two straight sections of channel-shaped, 16 gauge steel.⁶⁷

An extremely rugged field test was given both the Howe and Improved Zimmer litters:

1. Cross country carries with patients weighing approximately 200 pounds were made.
2. Loading and unloading patients from ambulances was carried out, as well as short drives over rough terrain.

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3. Tests were conducted during a steady rain and all movable parts of both litters were immersed in and covered with mud.
4. Both litters were dropped from a height of approximately two feet with a 200 pound patient. Handles of the litters were subjected to rough treatment and dropped on a concrete road from a distance of approximately two feet.
5. Short hauls were made carrying two patients weighing approximately 200 pounds each, a total of 400 pounds.⁶⁸

The showing of the Howe litter under these conditions was not favorable. Whipping action of the poles was excessive, estimated at about 1-1/2 inches, and appreciably added to the strain of the litter bearers. The patient complained of the spreader bar protruding into his back and causing discomfort. The grooved surfaces of the handles left deep imprints on the hands of the litter bearers which were painful even on short hauls. The stirrups showed outward displacement and scored the floor of the ambulance during loading and unloading. Under loads in excess of 200 pounds, there was a definite and permanent bowing of the steel frames.⁶⁹

On the basis of these tests, the Medical Equipment Laboratory recommended rejection of the Howe litter, listing the disadvantages as follows: (1) weight exceeded that of the aluminum litter by 2-1/2 pounds; (2) the steel poles were not sufficiently rigid; (3) the stirrups did not retain their original shape under heavy loads; (4) the spreader bars were weak, as well as uncomfortable; (5) the four additional holes required in the poles and canvas for attaching the stirrups weakened both the canvas and the poles; (6) in sum, the Howe litter was not sufficiently rugged for field use.⁷⁰

Informed of the adverse decision of the Laboratory at Carlisle, Howe Folding Furniture, Incorporated replied that it had submitted a rough, experimental litter model merely for inspection purposes; that it had wished to have the principle of construction employed therein commented upon, prior to making up a finished unit for extensive field testing.⁷¹ If this was true, it simply meant that the company had entered the picture too late to compete successfully with other concerns that had been working on the problem for many months. Before Howe Folding Furniture, Incorporated could possibly have submitted their "finished unit", a satisfactory substitute for the standard aluminum litter had already been found.

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I. Zimmer-Thomson Corporation; New York, New York.

Now that development of the Zimmer all-steel litter had reached an advanced stage, Medical Department negotiations were transferred from the Zimmer Splint Company to its manufacturing affiliate, Zimmer-Thomson Corporation, also of New York City. It will be recalled that, after the second series of tests on this litter, only the stirrup assembly remained to be perfected. Litter poles, handles, and spreader bars had already been approved by the testing agency. In the latter part of October, 1941, a third Zimmer model was submitted to the Laboratory at Carlisle, embodying a new stirrup construction. On 31 October 1941, the improved Zimmer litter was sent to the 32nd Medical Battalion, along with the Howe litter, for final test.

The new stirrups of this litter were formed from 13 BW gauge, cold rolled steel, 1-5/8 inches wide. The spacing of the stirrups was 49-1/2 inches overall, to conform to the standard adopted by the Navy. All non-movable parts of the undercarriage were spot welded, and all parts were cadmium plated. The entire assembly was described by the Laboratory as durable, rugged, and engineered for mass production at low cost. Each stirrup-spreader bar assembly weighed 3-1/2 pounds.⁷²

The field tests were identical with those to which the Howe litter was subjected, and have already been described in detail.⁷³ The 32nd Medical Battalion reported the results of these tests as follows: (1) the poles of the Zimmer litter set up little whipping action, bending only about 1/2 inch which did not interfere with the carrying of the patient; there was no permanent bending of the poles under excessive weight, nor was there excess stretching of the canvas; (2) the stirrups showed neither outward or inward displacement in loading and unloading operations, and the spreader bars held their positions and showed no tendency to bend or collapse during ambulance hauls over rough terrain; (3) rain and mud did not interfere with the operation of the spreader bars; after 24 hours the dried and caked mud did not interfere with the opening and closing of the bars.⁷⁴

In presenting its report of recommendation to the Medical Department Board, the Equipment Laboratory pointed out that already the Office of Production Management had advised The Surgeon General that aluminum would no longer be authorized for straight pole litters, and that consequently procurement of the standard litter had now ceased. The Laboratory added that the field of plastic materials had been thoroughly investigated, and that it could be definitely stated that there was no plastic then on the market, regardless of price or availability, that would be satisfactory

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for a field litter. Summary of the tests of other wood or steel litters was given. After describing the Zimmer all-steel litter (see Fig. 6) and the latest test results, the Laboratory concluded by observing that the steel used in the construction was available for almost immediate delivery in unlimited quantities, and that the complete litter could be supplied at a cost of less than \$8.00, if ordered in reasonably large quantity.⁷⁵

The Medical Department Board, in its formal report to The Surgeon General's Office, concluded as follows:

Conclusions of the Medical Department Board: The litter under consideration whose structural parts are made entirely of plain carbon steel, and which has undergone extensive laboratory and field tests, shows itself to be in every respect equal to the standard aluminum pole litter, except for its weight; and without exception superior to the wooden pole litter.

Recommendations: It is recommended that the steel pole litter with pressed steel stirrup spreader bar assembly, as developed by the Medical Department Equipment Laboratory, be adopted as standard in the Medical Department of the United States Army.⁷⁶

J. Simmons Company; New York, New York.

Pending final action on the Zimmer litter, two more litter models were to be tested before the first phase of Development Project, F-11 came to an end. The first model was submitted by the Simmons Company of New York City (factory at Kenosha, Wisconsin), after their engineers had visited the Laboratory at Carlisle in the early part of January, 1942, and obtained the latest information regarding the progress of the development project.⁷⁷

On 3 February 1942, two Simmons litters were forwarded to the 32nd Medical Battalion for field testing. Both were made almost entirely of carbon steel, with stirrup and spreader bar assemblies fabricated from pressed steel. One of the litters was provided with wooden handles, the other with steel handles. Standard tests, similar to those applied to the Zimmer and Howe litters, were requested by the Laboratory.⁷⁸

In its report, dated 10 February 1942, the 32nd Medical Battalion presented the following findings: (1) during cross-country carries there was little whipping action of the poles of either litter, but some sag developed in both

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cases; (2) in hauling over rough terrain with a patient load, the side poles bent into an arc of 2 feet in the wooden-handled litter and 3/4 inch in the metal-handled litter; (3) the hinges of the stirrup and spreader bar assembly became loose on both litters, after they had been opened and closed several times. In conclusion, the testing agency recommended rejection of both Simmons litters as unsuitable for military use, and this recommendation was sustained by the Medical Department Equipment Laboratory.⁷⁹

K. Ellwood Products Corporation; Ellwood City, Pennsylvania.

On 15 April 1942, a litter manufactured by Ellwood Products Corporation of Ellwood City, Pennsylvania was received by The Surgeon General's Office. Three days later this model was duly forwarded to the Medical Department Equipment Laboratory at Carlisle for full field test.⁸⁰ On 8 May 1942, the Laboratory rendered the following report of service test results:

The weight of this litter is approximately 17 pounds. This light weight was obtained by the use of alloy steel (apparently chrome-molybdenum) for the construction of all component parts. Alloy steel, being equally as strategic as aluminum, will not be available for Medical Department litters. If the design of the subject litter were duplicated in carbon steel to provide equal strength it is estimated that its weight would be increased about 7 pounds, (the present standard steel pole litter, weight 22 pounds, is constructed entirely of carbon steel).

The subject litter possesses two serious inherent defects:

- a. Spreader bar cuts the canvas when folded.
- b. Folding stirrups are too fragile to withstand field service.

Recommendations: It is recommended that subject litter not be adopted by the Medical Department.⁸¹

The foregoing information was summarized, on 11 May 1942, in a letter from The Surgeon General's Office to the manufacturer. On 21 May 1942, the Ellwood Products Corporation replied as follows:

In the sheets of explanation which we attached and sent with our litter we felt that we had not only explained, but made perfectly

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clear that the model that we were presenting was a hand made item and that it was to show functional design rather than how strong it could be possibly made. Notation was made in the last paragraph of our explanatory notes that Army requirements might call for greater massiveness of the parts to withstand extremely harsh tests.

In making our litter we have been in an unfortunate position in as much that definite testing procedures have not been available to us and that definite requirements as to weight tests, as well as rigidity tests, was not available....⁸²

The foregoing letter, addressed to The Surgeon General's Office, was immediately forwarded to the Medical Department Equipment Laboratory for answer. In its reply, on 28 May 1942, the Laboratory carefully elaborated on the service test results, and explained in detail why the Ellwood litter had been rejected. At the conclusion of this report, however, the following recommendations were stated:

- Recommendations: It is recommended that
- a. The folding feet not be adopted for the straight pole litter for the reasons cited in Paragraph 4 above.
 - b. The Ellwood Products Corporation be advised that their folding stirrup assembly may have possibilities for use on the folding pole litter.
 - c. That if the Ellwood Products Corporation are interested in the development of their folding foot-feature that they submit to the Equipment Laboratory a stirrup-spreader bar assembly conforming in general to the design shown on our Drawing No. D-330 and D-269, incorporating their folding stirrup.⁸³

Before discussing the various aspects of this case, it is first pertinent to inquire whether the Ellwood Products Corporation had simply submitted a sample litter on its own initiative, or whether it had been requested to do so by one of the agencies of the Medical Department. In its Monthly Progress Report for May, 1942, the Medical Department Equipment Laboratory stated that the Ellwood Products Corporation had been contacted by The Surgeon General's Office with regard to developing a litter of this type.⁸⁴ If such was the case, it is apparent that this action worked considerable hardship on the manufacturer.

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In the first place, the poles of the Ellwood Products litter were constructed of alloy steel (apparently chrome-molybdenum). Alloy steels generally had been formally rejected by the Laboratory at Carlisle fully seven months before, and there appears to be no evidence that a change in the status of this critical material had occurred in the meantime which would have warranted resubmission of litter poles made of such metal.

Secondly, as in the case of the Howe Folding Furniture, Incorporated, the manufacturer seems to have been laboring under a misapprehension both as to the extreme importance of the time element in this search for aluminum substitutes, and also with regard to the advanced stage that had already been reached in the development of a new straight pole litter. It will be recalled that on 3 January 1942, three months before the Ellwood Products litter had been submitted to The Surgeon General's Office, the Zimmer all-steel litter had been formally approved by the Medical Department Board. Moreover, on 5 June 1942, less than ten days after the reply to the manufacturer cited above, actual procurement of the Zimmer litter was initiated by the Medical Department.⁸⁵

Finally, the inability of the company to obtain necessary information regarding testing procedures and strength and rigidity requirements, would seem to indicate that working through The Surgeon General's Office, rather than directly with the Laboratory at Carlisle, had been a handicap. This conclusion is further supported by the fact that only after an energetic follow-up by the company was the information forthcoming that the folding feet feature of its model, while unsuitable for the straight pole litter, was thought to have possibilities for use on the folding pole litter.

This case once again raises questions as to the most effective division of function between The Surgeon General's Office and the Medical Department Equipment Laboratory on matters of manufacturer relationship. It also emphasizes in rather pointed fashion the continual need for the closest coordination between these two Medical Department agencies if the maximum contribution of private industry to medical research and development is to be obtained.

IV. Standardization and Procurement Phase (1) (The Steel Litter).

A. Standardization.

On 3 January 1942, the proceedings of the Medical Department Board, Carlisle Barracks, Pennsylvania, recommending adoption of the Zimmer all-steel straight pole litter as a

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standard Medical Department supply item, were forwarded to The Surgeon General's Office. On the same day, drawings and specifications for the new litter were prepared by the Medical Department Equipment Laboratory and sent to The Surgeon General's Office for approval.⁸⁶

From this point on, Medical Department action was subject to the standardization procedures stipulated in AR 850-25. These regulations prescribed: (1) preparation of military characteristics, specifications, basis of issue, and procurement statistics by the technical service charged with the development and procurement of the item; (2) formal coordination of this data through the technical committee of the service concerned for concurrence by other arms and services; (3) approval by the chief of the appropriate technical service; (4) forwarding of standardization data to the Adjutant General for final approval by the Secretary of War.⁸⁷

For the entire period in question, careful examination was made of the Minutes of the Medical Department Technical Committee, Monthly Status Reports submitted by research and development subdivisions of The Surgeon General's Office, and, finally, Record Room (Surgeon General's Office) files of official correspondence dealing with litter development. No evidence was found which would indicate that the Zimmer steel pole litter was ever formally processed for standardization through the Medical Department Technical Committee. There is an equal lack of positive evidence, in the sources consulted, that complete standardization data were either prepared by the Medical Department or processed through the higher channels of authority, as required by regulations.

B. Procurement.

Although the straight steel litter was not added to the Medical Supply Catalog until 3 November 1942,⁸⁸ the initial order for procurement of this item was placed 5 June 1942. This award was split between two contractors, one receiving an order for the delivery of 10,000 steel litters at \$7.51 each, F.O.B. destination, while the other was awarded a contract to supply 20,000 steel litters at \$7.59 each, also F.O.B. destination. Deliveries throughout the month of June, 1942, totaled 6,030. During July, 1942, an additional 12,962 litters were shipped to supply depots, and the undelivered balance of the original order was received by 19 August 1942.⁸⁹

In other words, 30,000 straight steel litters had been manufactured and delivered at relatively low cost to Army supply installations within two and a half months after the placing of the initial contracts. As we shall see subsequently, compared to the procurement history of certain other

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newly developed litters, this was a remarkable record. Moreover, the production cost of the new steel litters was to decrease with the passage of time. Since August, 1942, unit cost has dropped from \$6.30 to \$4.87, F.O.B. point of origin.⁹⁰ This price reduction has been due in large part to the greatly increased requirements for steel litters since 1942.

Upon the outbreak of World War II, the only straight pole litter which the Medical Department had in stock in any quantity was the ash pole litter. At this time only about 3,000 of the aluminum pole litters with cast aluminum under-carriages had been purchased, and the new extruded aluminum running gear was just getting into procurement.⁹¹ The following table will indicate the radical changes that had taken place in the procurement picture by 30 September 1943.⁹²

	<u>Net Stock</u> <u>1 Jan. 43</u>	<u>Deliveries</u> <u>1 Jan. 43</u> <u>to</u> <u>30 Sep. 43</u>	<u>Issues</u> <u>1 Jan. 43</u> <u>to</u> <u>30 Sep. 43</u>	<u>Net Stock</u> <u>30 Sep. 43</u>
78440 Litter (ash pole)	8,984	-----	9,396	7,830
99350 Litter, straight, aluminum	7,802	-----	4,335	6,657
99376 Litter, straight, steel	11,384	334,223	125,097	147,599

As of 25 January 1945, total deliveries of the straight steel litter amounted to 471,317, balance undelivered--none. At present time there is a negotiation in process to procure 15,000 more of these litters.⁹³ From this data it is clear that the standard steel litter has, in reality, been the backbone of the system of medical evacuation in World War II.

V. Evaluation (1) (The Steel Litter).

A. The Race Against Time.

On 3 January 1942, the Medical Department Board officially recommended adoption of the Zimmer all-steel litter as a standard catalog item to be used in place of the straight pole aluminum litter if and when that item became unavailable to the Medical Department. On the same day, drawings and specifications were forwarded to The Surgeon General's Office by the Medical Department Equipment Laboratory.⁹⁴ In other words a satisfactory substitute litter had now been fully developed and, except for the fulfillment of procedural requirements in connection with formal standardization, was ready for immediate procurement.

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On 3 March 1942, exactly two months later, the Office of the Under-Secretary of War issued its official order forbidding further use of aluminum in the manufacture of the straight pole litter.⁹⁵ The race against time, then, had unquestionably been won. In this respect it is evident that development activities were completely successful. What may be said, however, of the quality of the substitute litter that was produced? Was it actually serviceable in the field? How did it compare with the ash pole litter of World War I? How did it compare with the standard aluminum litter? Is it today the litter of choice in the Medical Department?

B. The Steel Litter versus The Ash Pole Litter.

There is no real question as to the field serviceability of the steel litter. With total procurement up to the present time approximating the half-million mark, it is obvious that the new litter has found wide acceptance by medical field personnel. The question remains, however, as to the comparative quality of the steel litter, since neither the ash pole nor the aluminum litters were procurable during this period due to shortages in construction material. First we shall compare the new steel litter with the World War I ash pole litter.

In January, 1942, after reviewing the reports of comparative field tests of both the steel and ash pole litters, the Medical Department Board gave its conclusions as follows:

The litter under construction whose structural parts are made entirely of plain carbon steel, and which has undergone extensive laboratory and field tests, shows itself to be... without exception superior to the wooden pole litter.⁹⁶

Comparing the two litters, component for component, the above evaluation would seem relatively noncontroversial except in one respect. It would seem evident that the pressed steel undercarriage of the Zimmer litter was a decided improvement over the cast iron running gear of the ash pole model. It weighed three pounds less, it was subsequently found to be exceptionally serviceable, and it involved the use of no critical materials. Similarly, as was pointed out in the case of the standard aluminum litter, the smooth wooden handle inserts were demonstrably more comfortable and vastly more efficient from a maintenance standpoint than were the improvised handles of the ash pole litter which remained an integral part of the side poles.

So far as over-all weight was concerned, there was little difference between the two litters. Both weighed approximately 22 pounds. However, the carbon steel tubing of

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the Zimmer litter weighed nearly five pounds more than the wooden side poles of the World War I litter. This, clearly, was a decided disadvantage. There were, of course, compensations for the weight factor. In the summer of 1942, one manufacturer who had supplied both types of litter for the Medical Department explained his preference for steel tubing as against ash poles as follows:

... steel poles are much cheaper, more readily available (both goodly supply and rapid delivery), less deflection (patient bounce), more durable (not subject to dry rot or termites), require less canvas, said canvas more quickly replaceable....⁹⁷

Recalling the discussion of the aluminum pole litter, it will be remembered that the slip-on method of attaching the canvas cover to the side poles was found greatly superior, in terms of cost, ease of maintenance, and salvageability, to the system of employing 142 tacks, 9 screws, 2 rings and 2 studs. Thus far, slip-on canvas had been found practicable only with round side poles, so this factor constituted an important counterbalance to the weight disadvantage of the steel poles.

By and large, therefore, while it would be difficult to agree that the new steel litter was "without exception superior to the wooden pole litter", it did appear to be superior on most counts. The most cogent fact of all, perhaps, was this. Procurement of the ash pole litter was discontinued entirely by December, 1941, was never resumed, and the item was formally reclassified to Limited Standard in July, 1943. These actions indicated rather conclusively that the wooden litter had been definitely supplanted by the steel and aluminum litters, regardless of the future availability of straight grain ash wood.

C. The Steel Litter versus The Aluminum Litter.

Again quoting the Medical Department Board in its official report of 3 January 1942, the following conclusion was given with respect to the relative merits of the steel and aluminum litters:

Extensive tests indicate that this litter /steel/ is superior in every respect to the standard aluminum litter except for the weight.⁹⁸

As in the case of the ash pole litter, the Board's estimate would appear to be somewhat over-optimistic. In

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many respects the two litters were identical. The same dimension canvas was used, the same slip-on method of attaching the cover to the side poles was employed, and the same wooden handle inserts were specified. On the other hand, the greater weight of the steel litter was due to two factors; its carbon steel poles and its pressed steel undercarriage, each in turn weighing more than the corresponding component of the aluminum litter.

As for the side poles, it would be difficult to find a sound basis for preferring the steel tubing to the aluminum. Both have withstood the most rugged field service, were equally easy to maintain in the field, and the aluminum poles had the added virtue of being appreciably lighter. Regarding the two undercarriages, however, the added weight of the pressed steel running gear was amply compensated by its greatly superior durability.

The stirrup spreader bar assembly of this litter /steel/ is considerably more rugged and durable than the cast aluminum stirrup spreader bar assembly of the standard /aluminum/ litter.⁹⁹

How, though, did the pressed steel undercarriage compare with the extruded aluminum gear developed in the summer of 1941? The extruded assembly, it will be recalled, weighed nearly 1/2 pound less than the cast aluminum. Once again, as we shall see in a moment, the Medical Department felt that the markedly superior durability in the field of the pressed steel stirrup and spreader bar assembly amply justified the weight increase.

It is, therefore, not easy to establish a valid preference for either the steel or the aluminum litter as a complete unit. The pressed steel undercarriage of the steel litter was preferable, in the judgment of both research and procurement officials, to either the cast or extruded aluminum assemblies of the aluminum litter. On the other hand, there was an equally emphatic preference for aluminum over carbon steel for litter poles.

D. The Litter of Choice of the Medical Department.

The litter of choice of the Medical Department, toward the close of 1943, was neither the standard aluminum pole litter nor the straight steel litter, but a combination of the two. On 20 October 1943, Colonel Paul I. Robinson described what was then, in the view of the Medical Department, the ideal straight pole litter:

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The straight pole aluminum litter with pressed steel stirrups and spreader bars, which... have proved more durable in the field, is considered the most desirable of the straight pole litters and it is believed that aluminum can be obtained in sufficient quantities to take care of requirements.¹

With the removal of duraluminum tubing from the War Department list of scarce materials, and with the development in 1945 of a universal pressed steel undercarriage designed to fit all of the various straight pole litter types then under procurement, the desired changeover from carbon steel to aluminum side poles was at last possible. Accordingly in June, 1945, the straight steel litter was officially reclassified to Limited Standard, thus leaving the straight aluminum litter (with new universal undercarriage) in undisputed top position.²

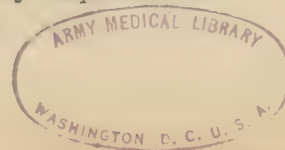
E. Conclusion.

In 1941, the growing threat of an acute aluminum shortage had presented a serious challenge to the Medical Department and to the whole system of medical evacuation. Not only was this immediate challenge effectively met by Medical Department research and development personnel, but in the process highly significant technical contributions were made which advanced our knowledge of litter construction far beyond the level which had obtained prior to the outbreak of World War II.

First, an extruded aluminum undercarriage was designed and adopted in 1941 which proved to be greatly superior, both in terms of weight and durability, to the cast aluminum assembly which had previously been procured. Second, a satisfactory substitute for the aluminum pole litter was developed--and in time to maintain an uninterrupted flow of litters to supply depots both in this country and abroad in spite of the aluminum shortage of 1942. Finally, a pressed steel undercarriage was designed and adopted in 1942 which was ultimately to become the component of choice in the Medical Department, to be procured in preference to the cast and extruded aluminum assemblies.

Thus, despite the failure on the part of Medical Department research and development personnel to adhere strictly to the procedures prescribed in AR 850-25 for project initiation and item standardization, and despite certain violations of established principles of administrative coordination, the results attained in this first phase of Development Project, F-11 were definitely impressive.

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There can be little doubt that the Medical Department had, thus far, given an excellent account of itself.

VI. Development Phase (2) (The Laminated Wood Litter).

A. Introduction.

Having forwarded to The Surgeon General's Office, on 3 January 1942, final drawings and specifications for the Zimmer all-steel litter, the Equipment Laboratory shifted its attention from the straight pole litter program to other fields of Medical Department research. In its Monthly Progress Report for April, 1942, the Laboratory listed Development Project, F-11 as completed, and estimated that no funds either for civilian personnel or for supplies would be required for fiscal years 1943 or 1944, unless The Surgeon General's Office should desire to have the investigation reopened.³

For the next three months, aside from two comparatively minor activities, nothing of a formal nature was undertaken in the field of straight pole litter development. In May, 1942, as mentioned earlier, a chrome-molybdenum litter manufactured by Ellwood Products Corporation was tested and reported upon.⁴ During the following month, at the request of the New York Medical Depot, the Laboratory adapted the design of the pressed steel stirrup and spreader bar assembly for use with the ash pole litter which was still, technically, a standard item although it had not been under procurement since the latter part of 1941. Drawings and specifications covering this adaptation were forwarded to the Medical Depot on 4 July 1942.⁵

By the early part of August, 1942, however, the litter picture had begun to change. Several disturbing signs of a possible shortage in steel were beginning to appear. For several weeks the facts were inconclusive but, by the end of the month, action was taken by the Federal Government which left little doubt as to the proximity of the danger.

It is the opinion of this office that the Research and Development Section of The Surgeon General's Office should encourage work in the substitute for steel in the straight pole litter. Your information that steel is plentiful is in error. Steel is getting tighter every day, and this office has had to appear before the

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WPB and defend all usage of steel. It is not our desire to change to the wooden substitute, but we should be ready should steel be denied.⁶

In view of these developments, in September, 1942, The Surgeon General's Office reopened the investigation of substitute materials for the straight pole litter.⁷ It had been implied in the above communication that at least a stop-gap solution could be found by merely shifting procurement from steel to ash pole litters. It was immediately evident to the Medical Department, however, that the situation could not be met in that way. For one thing, the marked inferiority of the World War I litter was a serious drawback to such a plan. Furthermore, due to the increasing scarcity of canvas, it was impossible to discard the great quantities of this material which had been manufactured according to the slip-on specifications of the aluminum and steel pole litters.

Finally, and this was the decisive point, it had been a grave question for nearly a year whether straight grain ash could be procured in sufficient quantity for Medical Department needs, and there was as yet no indication that this situation had improved. In short, it was going to be necessary to discover and develop a new substitute material which could be used satisfactorily for litter construction.

However, as we have already seen, research possibilities had now been narrowed almost to the vanishing point. Aluminum was already on the critical list, as were the alloy steels like chrome-molybdenum. Plastics and hard rubber had been thoroughly investigated, and had been found wholly impracticable. It was evident that the task of finding an adequate substitute for carbon steel was not going to be an easy one. Moreover, under the pressure of the impending shortage, speed was again essential. Thus, though the obstacles had been multiplied, Medical Department research and development personnel were to be engaged in another crucial race against time.

B. William A. Savage; Randolph, Vermont.

On 4 September 1942, The Surgeon General's Office forwarded to the Medical Department Equipment Laboratory a wooden pole litter, built and designed by William A. Savage of Randolph, Vermont. It was requested that the new litter be given a field test to determine its suitability as a replacement for the standard steel and ash pole litters.⁸

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The solid ash side poles of the Savage litter were of the conventional wooden type with nailed-on canvas, similar to the World War I design except that the poles were grooved on two lateral sides to accommodate a sliding steel plate, which in turn was connected to the spreader bar. The spreader bar was a single, instead of double, assembly and consisted of two pieces of hard wood crossed in the center and forming an "X", so riveted that relatively free movement was possible. Two ends of the "X" were riveted to the under-sides of the poles, while the other two ends were fastened to the two small steel plates which fit into grooves in the poles. When the litter was opened, the "X" expanded and, by means of small set screws in the sliding steel plates, could be fixed in that position. The stirrups, which were entirely separate from the spreader bars, were simply small hard wood blocks mortised in the under-sides of the litter poles, where they were glued and nailed.⁹

Since this experimental model had been constructed largely of straight grain ash and steel, both potentially scarce materials, it offered no solution whatever to the immediate problem confronting the Medical Department. However, in his design the inventor had introduced several interesting innovations which, if found practicable, could influence materially the course of subsequent litter research. The Savage model was, therefore, subjected to the regular field tests, and in a few weeks the results were announced.¹⁰

(1) A 200-pound patient was carried by litter bearers and hauled by ambulance without producing either excessive whipping or bowing of the poles. (2) The litter was dropped on the pavement so that it landed on its stirrups, and efforts were made to twist the side poles. Upon completion of these tests, the metal slides appeared slightly bent, and operated thereafter with difficulty. (3) The effect of mud on the slides was tested by dropping the litter in mud holes, and it was found that mud did impair the opening and closing of the litter. When dried and cleaned, the slides functioned smoothly, but each successive test made the spreader bar operation more difficult. (4) The open litter was then immersed in water for a few hours and allowed to dry. It was found that the tight canvas turned the poles out to such a degree that the spreader bar could not be opened or closed except by pounding. In addition, water apparently entered the mortise in the poles where the wooden stirrups were inserted, and the swelling which resulted split the poles for a distance of 5 to 6 inches.¹¹

In a formal report, dated 16 September 1942, the Medical Department Equipment Laboratory rejected the Savage litter as a replacement for the standard steel or wood pole litters with the following comment:

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- (1) Metal slides in stretcher bar assembly and the principle of their operation depend upon the litter poles remaining perfectly straight. Wet canvas or twisting of poles cause slides to bend and impair operation.
- (2) Mortises of the wooden stirrups in the litter poles weaken the poles and when water or moisture enter, cause swelling and splitting of poles.
- (3) The set screw assembly to hold the slides to the poles when the litter is opened are too fragile, will rust, and if broken off, render the litter useless unless replaced. Replacement leaves an unpeened screw which will shake out and become lost. To repeen requires complete disassembling of the spreader bar; a difficult job requiring filing off the heads of the rivets.¹²

While the results of this investigation were negative, the mere fact that field tests had been conducted at all indicated the willingness of Medical Department personnel to explore all possibilities. Since no further modifications of the World War I design were presented, this was the last instance of experimentation involving solid ash poles.

C. Lawrence Woodworking Company; Lawrence, Kansas.

On 28 September 1942, eight plywood litter poles, manufactured by the Lawrence Woodworking Company of Lawrence, Kansas, were received by the Medical Department Equipment Laboratory.¹³ This company, which had been in contact with The Surgeon General's Office since the early part of September, had followed very closely the dimensions of the straight aluminum pole. The plywood tubing had an outside diameter of 1.54 inches and was 90 inches long. These poles, which had been procured under an AAL priority, were furnished to the Medical Department at \$1.00 each, which was decidedly less than the cost of either aluminum or carbon steel tubing.¹⁴

Upon receipt of the eight plywood tubes, the Laboratory had them inserted into standard frames, and the four completed litters were then subjected to field tests. It is not evident from the data at hand whether these experimental poles were tested by the 32nd Medical Battalion or by the Laboratory itself, but on 1 October 1942, the following report was submitted to The Surgeon General's Office by the Medical Department Equipment Laboratory:

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In comparing the plywood tubes to various types of standard litter poles now used by the Medical Department, the following objectionable features in the plywood tubes were disclosed:

- a. Flexibility of the plywood tube is excessive, causing the litter assembled with this type of litter pole to develop a whipping action which is not compatible with the degree of comfort required in the transport of casualties.
- b. The strength of the plywood pole in regard to their ability to support the given weight is about half of that of standard litter poles. The maximum weight that the plywood pole is capable of supporting is 160 pounds, whereas, the standard litter pole is capable of supporting up to 300 pounds.
- c. In addition to having too great flexibility and too little strength, the plywood poles were found to be quite easily broken when sudden stress is applied.¹⁵

While the test results described above afforded considerable evidence of the unsuitability of plywood for the construction of litter poles, the Equipment Laboratory preferred to engage in further experimentation before arriving at a final decision. It was announced that other plywood tubes were to be received in the near future, and that these would be service tested and reported upon as soon as possible.¹⁶

D. Hermisdorf Fixture Manufacturing Company; Manchester, New Hampshire.

The second venture with plywood tubes was initiated, oddly enough, not by a Medical Department agency, but by the War Production Board. On 5 November 1942, the Hermisdorf Fixture Manufacturing Company of Manchester, New Hampshire wrote as follows to the Conservation Division of the War Production Board.

This will acknowledge receipt of the experimental order placed with us today for 4 plywood tubes 90 inches long, diameter 1-1/2 to 1-5/8 inches, totalling \$10.00. These tubes are to be shipped to Col. E.D. Quinnell, Director, Medical Department Equipment Laboratory, Carlisle Barracks, Carlisle, Pa.

It is our understanding that we will receive from Lt. Col. Klopp, Surgeon General's Office, U.S. Army a formal confirmation of this order.¹⁷

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On 16 November 1942, the Hermsdorf Fixture Manufacturing Company was given official confirmation of the experimental order by The Surgeon General's Office, which had already notified the Laboratory at Carlisle of the expected shipment of plywood tubes and had authorized payment out of regular research funds.¹⁸

Before shipping the poles, the manufacturer subjected them to a series of deflection tests. These tests indicated: (1) Under a weight of 34 pounds, distributed near the ends of the poles, mid-point deflection ranged from $1/16$ to $3/16$ of an inch in the four tubes tested; (2) Under a weight of 58 pounds, distributed throughout the length of the poles with the exception of the center, mid-point deflection ranged from $9/32$ to $1/2$ inch; (3) Under a weight of 108 pounds, distributed throughout the length of the poles and including the center, mid-point deflection ranged from $7/8$ to $1-1/32$ inches.¹⁹

Rigidity tests had, of course, been performed in the past on aluminum and carbon steel litter poles. On these occasions, although weights of 300 to 400 pounds were applied, mid-point deflection averaged only a fraction of an inch.²⁰ Consequently, the results in the present instance, where only trifling weights were involved, appeared to be altogether discouraging. However, on 23 November 1942, the above test data was forwarded to the War Production Board with these rather remarkable comments:

In all cases the weight of each pole is approximately 4 pounds, as the pole is very rigid. This rigidity may be more than required, in which case this extra stiffness will be reflected in a higher cost, and should less stiffness be required, the pole would be less expensive and also of less weight.²¹

It is probable that if the above test results had been submitted to the Equipment Laboratory instead of the War Production Board, drastic modification if not complete refabrication of the poles would have been requested. If a dead weight of 108 pounds produced a center deflection of more than 1 inch, what would happen to the poles under a 200-pound casualty load? The answer was too obvious to require field test confirmation.

The evidence at hand does not indicate that the War Production Board advanced this basic criticism of the plywood poles in its correspondence with the Hermsdorf Fixture Manufacturing Company. Instead, certain questions were raised by that agency with regard to the durability of the tubes in other respects. These matters were dealt with by the manufacturer in a letter dated 28 November 1942.

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In regard to the climatic conditions we furnished only the raw pole without any finish. However, this pole can be weather-proofed by a dipping process and also made resistant to gas and oils. It is bonded with Plaskon #250-2 process which we understand to be termite-proof.²²

On 5 December 1942, the Medical Department Equipment Laboratory issued its formal report on the Hermsdorf litter poles.

These poles have been received and inspected. They are composed of 5 or 6-ply birch, circular tubes, lap and spiral wound with solid cross core of plywood cemented by plaskon #250-2 process. All poles were found unsatisfactory for litter pole use for the following reasons:

- a. Poles too springy.
- b. No means of fastening on handles.
- c. Poles all warped on arrival; outer spiral coverings blistered and ends cracked.
- d. Solid cross core inserts, after little use, slide out readily.

Two additional poles were furnished by this company. One pole made similar to those mentioned above except made of 4-ply walnut and 1-ply birch. This pole also warped and blistered. The other pole was a solid cross plywood pole; this had also warped and showed a crack all the way down one side where cementing had pulled apart.²³

The Medical Department Equipment Laboratory, it will be remembered, had been anxious to perform at least one more series of tests on plywood poles before arriving at a final decision as to their suitability for Medical Department use. However, the condition of the Hermsdorf poles upon arrival at Carlisle was such that field testing was impossible. Since time was pressing, although the data was hardly more complete than it had been before, the Laboratory ventured its opinion:

From our inspection of these and previous plywood, round, tube poles, we believe that this method of pole making for litters will not be successful.²⁴

Because of the peculiarly unsatisfactory results that were obtained in this instance, the case of the Hermsdorf

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Fixture Manufacturing Company warrants careful examination. It has already been observed, in tracing the history of the steel litter, how a lack of proper coordination between Medical Department agencies served on several occasions to reduce the efficiency and increase the cost of research and development activities. The Hermsdorf case, by way of contrast, presents a unique situation, for here the breakdown in coordination was due to a more or less independent exercise of research authority by an agency wholly outside the Medical Department, in fact even outside the War Department.

Whether power was delegated or usurped in this instance is not evident from the data, but the fruits of the arrangement are perfectly clear. The failure of the Hermsdorf poles, due to insufficient strength and an excess of resiliency, was predictable from the moment the rigidity tests were conducted. Yet the manufacturer was under the impression that the tests indicated, if anything, that the poles were perhaps more rigid than necessary. This is direct evidence of a lack of proper research guidance, the function which the War Production Board had on this occasion assumed. Had the manufacturer been given adequate information as to the strength and rigidity requirements for Army litter construction, such an interpretation of the deflection test results would have been impossible.

The results speak for themselves. Upon arrival at Carlisle, the Hermsdorf poles were so badly warped, blistered, and cracked that it was impossible to insert them into standard litter frames for field testing. By way of contrast it may be remembered that the Lawrence Woodworking Company, working solely through Medical Department agencies, had been able to produce plywood poles which, while ultimately judged to be unsatisfactory, did at least retain their original shape during shipment, reached Carlisle in good condition, and were thereafter fully tested in the field. It is, of course, possible that the Hermsdorf Fixture Manufacturing Company might have done equally as well had it been working under similar close supervision of Medical Department research and development personnel.

This, unfortunately, was not to be the only instance of intervention by the War Production Board in Medical Department research activities. Eventually, the difficulties which arose from this continued overlapping of function forced the Medical Department to take decisive action. We shall see presently how the elimination of this administrative overlapping was finally accomplished.

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E. Weaver Piano Company, Incorporated; York, Pennsylvania.

Now that plywood had been temporarily abandoned, the direction which the search for carbon steel substitutes was next to take was indicated in the Laboratory's concluding remarks in its test report on the Hermsdorf poles.

It is our opinion that a solid, laminated pole with turned integral handles and rounded edges is the better approach to the problem. Poles of this type on hand appear to have good prospects.²⁵

Nearly three weeks before, on 13 November 1942, the efforts of the Weaver Piano Company, Incorporated of York, Pennsylvania had been enlisted in the attempt to find a suitable substitute for steel and aluminum. In this instance, however, in contrast to the Hermsdorf case, the manufacturer sought and obtained full information from the Medical Department regarding litter specifications. There were, of course, the usual delays arising from the fact that manufacturing relationships continued to be directly handled by two Medical Department agencies instead of one. On 13 November 1942, the Weaver Piano Company, Incorporated learned through The Surgeon General's Office of the need for a new straight pole litter, and was informed of certain of the requirements which would have to be met. On the following day the company wrote to the Laboratory at Carlisle for additional information.

Col. Klopp did tell us that these poles are 90" long; that the maximum diameter is 1-5/8"; that they should not weigh more than 8-1/2 pounds each and that the maximum deflection may be 1". We are not sure, however, of the amount of the load nor whether it is a distributed load to be carried by these Litter Poles in pairs or if it applies to each individual pole.

Will you please send us complete data regarding these Litter Poles so that we may go to work on it and submit ideas if we are able to develop practical ones.²⁶

The Laboratory replied by inviting the company to send one of its representatives to Carlisle to go into the matter in detail. A letter, dated 27 November 1942, from the manufacturer to The Surgeon General's Office, gives a clear picture of what was decided upon at the conference which was subsequently held at Carlisle.

After much discussion it was decided that we should make 4 sample poles of three-ply, with plies 1 and 3 running longitudinally and the

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center ply at right angles to plies 1 and 3. This would then be machined down to size with two of the samples machined octagonal in shape and two of the samples with corners rounded to a 3/8" radius. These would then be bored for the fittings.²⁷

Within three weeks, four of these crossbanded, laminated wood poles were fabricated by the Weaver Company, Incorporated and were forwarded to the Equipment Laboratory for field testing. On 23 December 1942, the Laboratory issued its formal report on the performance of the experimental poles.

Two types of laminated litter poles have been given thorough test by this Laboratory and the 32nd Medical Battalion.

Pole "A" was manufactured by Weaver Piano Company, York, Pennsylvania. This pole was furnished in two types; one square with rounded edges and the other octagonal. Both poles were 1-5/8 inches in diameter. These poles were constructed of short pieces of alternating grain maple built between two full length side pieces.

This arrangement failed because poles fractured through the places where the grain was at right angles to the long dimension.

It is believed that if these maple poles had been made of continuous long pieces with grain running the long way as in Pole "B" that they would have stood up.²⁸

The foregoing report was not, it can be readily seen, altogether satisfactory. Once again, as in the case of the Lawrence Woodworking Company, there was no itemization of the field tests conducted by the 32nd Medical Battalion, no careful tabulation of the results of those individual tests. Likewise, there was no precise summary of findings, a feature which had been characteristic of all the earlier reports. In short, while the failure of the laminated poles was definitely stated and an explanation offered, little factual basis was afforded The Surgeon General's Office in writing for intelligent review of the Laboratory's actions and recommendations.

As for the Weaver Piano Company, Incorporated, although the test results had been negative, its efforts had been of genuine value, as the Laboratory readily acknowledged.²⁹ By devoting its attention to a particular type of pole construction which the Equipment Laboratory was anxious to have investigated, the company had definitely contributed to the solution of the over-all problem. The experiment had eliminated as a possibility the cross-banded type of laminated

pole, thus enabling research and development personnel to concentrate their efforts on the one remaining alternative. The nature of that alternative was suggested in the concluding paragraph of the above test report; a laminated pole with the grain in all plies running longitudinally.

F. Mikar Specialties Company; Baltimore, Maryland.

The successful development of a laminated straight pole litter was finally achieved by Mikar Specialties Company (Division of National Store Fixture Company) Baltimore, Maryland. The Surgeon General's Office first contacted this organization through one of its representatives on 31 October 1942.³⁰ Approximately one month later, one of the Medical Department's standard steel pole litters was shipped to the Mikar Specialties Company for its examination and study, and within several weeks a complete set of experimental laminated wood poles were forwarded to the Laboratory at Carlisle for field test.³¹

The new laminated poles were inserted into a standard litter frame, and the assembled litter was then tested by the 32nd Medical Battalion in comparison with the original ash pole litter. The tests conducted and the results which were obtained, were as follows:

- a. Litter supported 600 pounds in center without breaking.
- b. Carried patient, as in litter drill, no defects found.
- c. Litter tested in all berths of 1/2 ton ambulance, fitted properly.
- d. 200 pound patient carried in litter, slung in upper left berth of ambulance over rough terrain. Patient stayed in litter more comfortably than in standard litter.³²

The Commanding Officer of the testing battalion then presented his comparative findings.

Experimental litter is in my opinion equally as satisfactory as standard wooden pole litter, as shown in the above short tests, with the added advantage of being 5 pounds lighter.³³

Why these "short tests" were conducted, instead of the extensive and rugged field trials to which both the aluminum and steel pole litters had been subjected, was not explained. In view of the fact that the laminated wood model, if adopted, would presumably undergo just as rough treatment overseas as the standard litters then in use, the comparatively mild

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character of the present tests was, indeed, curious. It was true, however, that, in contrast to the cases of the Lawrence Woodworking Company and the Hermsdorf Manufacturing Company, in this instance a reasonably detailed test report had been submitted. If either the Laboratory or The Surgeon General's Office had been dissatisfied with the testing procedures employed, additional field trials could have been requested.

No criticism of the foregoing tests, however, was forthcoming. On 23 December 1942, the Medical Department Equipment Laboratory issued the following final report to The Surgeon General's Office:

This pole is square with rounded edges and is 1-1/2 inches in diameter. It is constructed of six ply laminated birch continuous pieces. These withstood testing very satisfactorily both in ambulance and manual carry. It showed no excessive resiliency under full load. A litter using this pole and the standard steel stirrup assembly weighed approximately 17 pounds and is in our opinion a satisfactory substitute for the standard wooden pole litter.

While all wooden poles are subject to defects and the strength and resiliency varies, a certain amount of breakage is expected as compared to metal poles. It is our opinion that...if made of selected 1st class wood and carefully glued the laminated pole would compare favorably as to breakage with the standard solid wood pole.³⁴

A few months later, the new laminated pole was subjected to a series of static weight tests by the Static Test Branch of the Aircraft Laboratory at Wright Field, Dayton, Ohio. Loads up to 1700 pounds were applied. No failure was noted in any part of the pole, and the permanent downward deflection which was produced was only 9/16 of an inch. It was concluded by the testing agency that the laminated wood litter was quite satisfactory for use in airplane ambulances.³⁵ Air Force Headquarters added its official approval of the new litter on 16 March 1943.

It is recommended that this litter be substituted for the steel pole litter for the Air Forces due to the lightness of the litter.³⁶

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Having received the approval both of the Medical Department Equipment Laboratory and Army Air Forces, the new laminated wood litter (see Fig. 7) was subsequently adopted as a standard item, listed in the Medical Supply Catalog, and placed under procurement. Two additional litter models, however, were to be tested before Development Project, F-11 was finally brought to a close.

G. Plymold Corporation; Lawrence, Massachusetts.

On 12 September 1942, just two weeks before the Lawrence Woodworking Company had completed its sample set of plytube poles, the Plymold Corporation of Lawrence, Massachusetts, at the suggestion of The Surgeon General's Office, undertook a parallel investigation of plywood tubing in order to hasten the final decision as to the suitability of this material for use as litter poles. Almost at the outset a controversy arose between Plymold Corporation and The Surgeon General's Office over the question of the size of tubing to be used in the construction of the experimental poles. Recalling our discussion of the principles of litter construction in Chapter I, it will be remembered that, due to the great number of variables involved, any attempt to redesign even a single litter component was beset with a surprising number of complications. As a practical illustration of the operation of these construction principles in actual development work, the arguments presented below are of special significance.

In a telegram to The Surgeon General's Office, dated 30 September 1942, Plymold Corporation maintained that, since an increase in pole size was necessary to produce aluminum tubing with the approximate strength of the standard steel tube, a corresponding increase in outside diameter was needed to produce plywood tubing of a strength sufficient for Medical Department needs.³⁷ The Surgeon General's Office replied by telegram, 1 October 1942, rejecting the proposed increase in pole size, but on the same day sent a letter to the Plymold Corporation explaining its decision.

Due to the number of factors involved, it is impossible to allow material increase in the diameter of the litter pole. Thousands of canvas covers are being produced and in order to use a larger pole, a change of specifications of the canvas cover would be necessary. Furthermore, the saddle which is arranged to fit either the 1-1/4" or 1-1/2" pole would have to be changed. This we cannot allow to be done because of the difficulty in using parts which would not be interchangeable with each other. It

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would probably mean that the canvas for one size litter pole would be shipped to one place and the pole or stirrups to another place. You see it is necessary for us to have our parts completely interchangeable so that if one part is destroyed, a replacement does not become difficult.³⁸

Agreeing that the rigidity normally possessed by 1-1/2 inch plywood tubing would be insufficient, The Surgeon General's Office offered this suggestion for increasing the strength of the pole:

...we see no reason why an inside plug would not only assist in lowering the amount of deflection, but would provide additional strength for the pole. I would suggest a plug of smaller diameter running midway through the center of the pole for about 2 feet.³⁹

Thus, the issue was settled, at least temporarily. No material increase in the diameter of the litter poles could be allowed for the reasons given. However, no sooner had this question been resolved than legal difficulties arose to delay further the experimental work. Plymold Corporation became the successor and assign of Lawrence Woodworking Company, and, in the course of that transfer, certain violations were alleged by the War Department which resulted in the issuance of a Suspension Order against the successor company.⁴⁰ Obviously, relief from the terms of this order was necessary before development work could proceed, as both delivery ratings and allocation priorities were affected. Consequently, at the request of the Conservation Division of the War Production Board, The Surgeon General's Office, and the Office of the Quartermaster General, temporary relief from Suspension Order S-98 was sought, and this was obtained 23 October 1942.⁴¹

It would have been supposed that no further question remained as to the impossibility of altering materially the outside diameter of the litter poles. Nevertheless, on 2 November 1942, the Plymold Corporation wrote The Surgeon General's Office, requesting drawings of the fittings in the ambulances and planes in which the standard litter was used. The reasons given for the request were as follows:

It is our understanding that the major limiting factor in the dimensions of the pole are set by the fittings used. In the event that we have these drawings available, we shall be in a position to determine what possible adjustments may be made in design in our poles to achieve maximum efficiency.⁴²

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The request was repeated on 12 November 1942, and five days later The Surgeon General's Office replied:

In response to your letters of November 2nd and November 12th, drawings of fittings of the ambulance and airplane cannot be furnished since they are classified documents.

Fittings are not the only reason why the dimensions of the poles are set. A number of other factors enter into the size and dimensions of the pole, one of which is the size of the loop in the canvas which cannot be changed since we have millions of pieces of this canvas already procured. Another is the saddle which holds the stirrup in place.

It is absolutely necessary that dimensions and specifications as previously given to you be complied with. If this cannot be done, it is requested that further development of this pole be discontinued.⁴³

No additional setbacks seem to have been encountered after this, and, in the early part of January, 1943, a set of experimental plytube poles were at last completed and shipped to the Laboratory for field test.⁴⁴ From the data at hand it does not appear that a written service test report was prepared by the 32nd Medical Battalion on the Plymold poles, nor that the customary formal report was submitted to The Surgeon General's Office by the Medical Department Equipment Laboratory. The only record that was found which described the performance of the plytube poles under field conditions was a letter from the Director of the Equipment Laboratory, dated 26 January 1942, and addressed to Paul R. Goldman, President, Plymold Corporation.

With reference to your telegram of January 25, I wish to advise that tests of your plytube litter poles show them to be unsatisfactory for the following reasons:

- a. Poles broke in the center when attempts were made to carry a 200 pound weight suspended.
- b. Poles exhibited too much resiliency and under load took a permanent set, making it necessary to strap a patient to a litter in order to carry same in our ambulance upper berth.
- c. Handle insert is too weak, either breaks off or splits end of pole.⁴⁵

Had there been any lingering doubt as to the unsuitability of plywood tubing for use in standard litters, they

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were surely dispelled now.

It appears that all attempts to make a circular plywood pole of multiple laminations will fail because of the nature of the load and the required methods of suspension. We have apparently solved the problem by use of solid laminated poles using six 1/4 inch thick laminations properly glued with water-proof resin glue.⁴⁶

- H. White Metal Rolling & Stamping Corporation; Brooklyn, New York.
Zimmer-Thomson Corporation; New York, New York.

On 10 September 1942, investigation of magnesium alloy, a metal which the Medical Department had not experimented with for some years, was reopened. The Equipment Laboratory, in response to a request for information from The Surgeon General's Office, forwarded this data concerning past tests of magnesium.

Reference your telephonic inquiry, this date, concerning the use of magnesium alloy for litters, I find that a couple of years ago we experimented with Dowmetal which is composed of magnesium which is alloyed with small quantities of aluminum, manganese and other metals.

Tubes of this metal, 1-1/2 inches in diameter by 1/8 inch thickness, as well as some solid poles were tested and found they lacked in stiffness and resiliency. They bent easily and took a permanent set.

Correspondence with the Dow Chemical Company, at that time, in which they were asked for suggestions as to what size Dowmetal would have to be used, they stated at least 1-3/4 inches by 1/8 inch or 2 inches by .095 inch wall. As the diameters suggested were considered too big, and the weight then would be the equal of the aluminum pole, no further research with this metal was made.⁴⁷

The above letter did not paint a particularly bright picture of the possibilities of magnesium alloy, but the White Metal Rolling & Stamping Corporation of Brooklyn, New York, which had been engaged in correspondence with The Surgeon General's Office regarding this metal, still contended the experiment was worth trying. In the first place, the company

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pointed out, there was a good chance that the tests made at Carlisle were conducted with a softer magnesium alloy than the one now proposed. The J-1 alloy currently suggested had, according to the company, a high tensile strength, and its yield strength could be increased by incorporating some cold working into the tube. Furthermore, by adopting a greater wall thickness, pole strength could be increased without enlarging outside diameter more than a fraction beyond the specified dimensions. The concern's final point was especially cogent.

We have had word that you are converting the litter production from aluminum to steel, which means that one less man can be carried per airplane with steel litters compared to magnesium litters with a normal complement of 18 litters per plane. Under this circumstance we would believe that it would be very important to save this lost payload....⁴⁸

It was decided, therefore, by The Surgeon General's Office that the experiment would be carried out as originally planned. By the middle of November, 1942, an official request was made through the Aluminum and Magnesium Branch of the War Production Board for approval of an experimental order of 10 tubes of magnesium alloy from the White Metal Rolling & Stamping Corporation.⁴⁹ Meanwhile, the Zimmer-Thomson Company of New York City had made arrangements with the tube manufacturer to assemble the new poles when completed into standard aluminum frames. By 19 October 1942, as a result of consultation between the two companies, a final decision was reached as to the size of the die from which the tubing samples were to be made.⁵⁰

Formal authorization from the War Production Board did not come through until December, 1942. Nevertheless, by the middle of January of the following year, fabrication of the magnesium alloy tubing had been completed, the new poles had been inserted into aluminum frames, and the experimental litters shipped to the Laboratory at Carlisle for field test.⁵¹ Four days after their arrival, on 19 January 1943, the Medical Department Equipment Laboratory submitted its formal test report to The Surgeon General's Office. Considering allocation difficulties, which had held up production for nearly two months, the development work cooperatively handled between the two manufacturers had been completed in a remarkably short time.

The magnesium pole litters were identical in design to the old standard aluminum litters, with the following exceptions: (1) outside diameter of the magnesium poles was 1-5/8 inches, as compared with 1-1/2 inches for the aluminum;

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(2) wall thickness of the new tubing was 10/64 inch, as against 7/64 inch for the aluminum tubes; (3) the magnesium litter, fully assembled, weighed 18 pounds, one pound more than the complete aluminum litter. In all other respects the two litters were the same. Both types of poles were equipped with standard wooden handle inserts, and the undercarriages of both litters consisted of the old-style aluminum stirrup and spreader bar assembly.⁵²

Tests of the magnesium pole litter in comparison with the aluminum pole litter yielded the following results: (1) With the litters placed on a hard floor and 150-pound weights applied to each at a central point over the hinges, the magnesium pole showed moderate sag, the aluminum pole showed none; (2) With a 185-pound man standing on the poles over the hinges, the magnesium pole again sagged more than the aluminum; (3) With a man jumping up and down on the litters, the aluminum pole remained straight while the magnesium showed a slight permanent bend; (4) A 215-pound man was placed on each litter, the litters were loaded into the upper berths of an ambulance which proceeded at a speed of from 5 to 8 miles per hour over moderately rough terrain. When supported by slings, the magnesium pole showed a definite bend in the half next to the head while no bend was observed in the aluminum pole. With the poles supported by brackets, there was very little bend in the magnesium pole, none in the aluminum. Similar tests, using a 170-pound man, produced a slight bowing in the magnesium pole but none in the aluminum; (5) In testing the litters on the floor, there was no bending in either case under the weight of a 185-pound man; (6) Testing with a four-man carry, with a 215-pound patient, and using litter straps to prevent bouncing, no permanent bending was noted in either pole; (7) A similar test performed without the use of litter straps produced some bowing in the magnesium pole, but no permanent bending resulted except when the patient was bounced.⁵³

Generalizing from the above tests, the Laboratory presented these findings:

The magnesium pole is rather soft and the exposed ends are easily damaged, also, frequent bending of the hinge and lateral twisting because of this softness caused the joint to become very loose....

The magnesium pole litter is heavier, and larger than the aluminum pole litter, and will not support over 180 pounds without strapping of the patient to prevent bouncing.

The metal is softer than aluminum and erodes more readily at the joint from frequent

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bending and side twisting leaving a wobbly joint.⁵⁴

In conclusion, it was recommended by the Laboratory that the magnesium alloy poles be rejected as a substitute item for use in the standard litter.⁵⁵

The new magnesium poles were subjected to one additional series of tests before the investigation was formally abandoned. On 2 February 1943, The Surgeon General's Office received from the Static Test Branch of the Aircraft Laboratory at Wright Field a static test report on four of the new Zimmer-Thomson magnesium pole models. Loads up to 1,000 pounds had been applied with the following results: (1) Under a 400-pound load, center deflection amounted to 13/16 inch; (2) An additional deflection of approximately 1-3/4 inches was obtained for each 200 pounds over and above the 400-pound load; (3) Total center deflection under the full 1,000-pound load was 6-3/4 inches; (4) The poles did not resume their original shape after completion of the tests.⁵⁶

I. Conclusion.

With both plywood and magnesium tubing now eliminated from further consideration, the tentatively approved laminated wood pole seemed ready to be processed for standardization and procurement. It will be recalled, however, that the laminated pole measured 1-1/2 inches in diameter, as compared with 1-1/4 inches for the carbon steel tubing. Since, as already pointed out in the Plymold case, large quantities of canvas had been procured according to the steel pole specifications, it was desirable to reduce the diameter size of the new laminated pole to 1-1/4 inches if at all possible. Therefore, in mid-February, 1943, a last attempt was made both to lighten the contemplated wood pole litter and also to make it adaptable to the existing stock of litter covers, by decreasing pole size. A 5-ply pole, 1-1/4 inches in diameter, and consisting of 1/4 inch birch strips was constructed by the National Store Fixture Company. Details as to the field tests to which it was subjected are lacking. However, the Laboratory reported that the new, smaller-dimension poles were found to lack the necessary rigidity.⁵⁷

The failure of this experiment established the 1-1/2 inch pole designed by the Mikar Specialties Company as the wooden pole of choice for the Laboratory at Carlisle, and within two months the new laminated poles were placed under procurement by the Medical Department. Since carbon steel was, even by this time, still available in adequate quantity, it was evident that Medical Department research

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and development personnel had won by a comfortable margin their second race against time. Ironically, the race had been won almost too handily, for a new problem now unexpectedly arose. What was to be done with the new laminated wood litter? Was it to supersede the standard steel model which was still readily procurable, or was it to be held in reserve? As we shall see presently, the procurement decision that was finally reached was more the product of events than of deliberation.

VII. Standardization and Procurement Phases (2) (The Straight Wood Litter; 1943 Model).

A. Standardization.

On 23 December 1942, the Medical Department Equipment Laboratory forwarded to The Surgeon General's Office its recommendation that the laminated wood pole be adopted as a substitute item for use in the standard litter.⁵⁸ Drawings and specifications for the new pole were submitted by the Laboratory on 8 January 1943.⁵⁹ From this point on, Medical Department action was once again subject to the standardization procedures stipulated in AR 850-25. These regulations, it will be recalled, specified that complete standardization data was to be prepared by research and development personnel in The Surgeon General's Office, coordinated through the Medical Department Technical Committee, and forwarded to higher authority for final approval.

All standardization data, it should be remembered, was to include certain specific information relating to procurement. Of the various procurement factors which, according to regulations, were to be carefully reported upon, two are of special interest here. First, detailed information was required as to sources of supply for the proposed item. The responsible arm or service was to state:

Whether, for the item to be procured for war, sources of supply have been investigated and the conclusion regarding sufficiency reached as a result thereof.

Whether, if to be procured from commercial sources, the characteristics of the item are such as to restrict the procurement to one source of supply.⁶⁰

Secondly, careful investigation was to be made of production costs. Unit costs were to be listed, with respect

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to (a) most recent procurement experience, and (b) estimated future requirements.⁶¹

Careful examination of the data at hand does not indicate that the laminated straight pole litter was processed through any of the steps outlined above. As in the case of the straight steel litter, non-observance of these Army Regulations did not produce any noticeable difficulties. However, it will presently be seen that, except for a fortuitous circumstance, failure to follow standardization procedures as specified in AR 850-25, especially the omission of a formal and recorded investigation of supply sources and production costs, might well have had a serious effect on subsequent procurement history.

B. Procurement.

Although apparently never formally processed for standardization, the new straight wood litter was added to the Medical Supply Catalog on 15 May 1943 as a standard item.⁶² The initial order for procurement had been placed about three weeks earlier, on 24 April 1943, at which time a contract had been awarded for the production of 5,363 laminated wood litters, at a cost of \$6.39 each. Delivery of the first 2,000 litters was remarkably prompt, as shipment was made before the close of May, 1943. Delivery of the remaining 3,363 litters, however, was delayed considerably, the litters finally arriving 13 September 1943. Procurement of the straight wood litter was thereafter discontinued, and up to the present time no further orders have been placed for this item.⁶³

The immediate cause of this extraordinarily light procurement of the laminated wood litter was the restoration of aluminum to the War Department list of available production materials. On 16 August 1943, the following Memorandum was issued to all Technical Services of the Army by Headquarters, Army Service Forces. . .

Paragraph 3. This improvement in the availability of aluminum precludes the need for further conservation. Items which now specify aluminum need not be changed to other materials. The Technical Services may plan to reinstate aluminum castings and powder from medium and low grade metal where less desirable substitutes are being used. To a limited extent such wrought products as tubing and sheet, strip, plate, and foil may be used. New uses with these same products and grades of aluminum may also be considered.⁶⁴

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With aluminum again available, there was little question as to the preference of the Medical Department. The standard aluminum litter was lighter than the laminated wood model, it made use of the standard wooden handle inserts, and the aluminum tubing possessed a strength and rigidity clearly surpassing that of the laminated poles. Thus it was that events rather than deliberation decided the fate of the straight wood litter.

However, since the release of aluminum from the list of critical materials was largely an unforeseen coincidence, it is pertinent to any final appraisal of Development Project, F-11 to examine a bit further the procurement possibilities of the straight wood litter. Had aluminum not been available at precisely this moment, the question of procurability of the laminated wood model would have been of the utmost importance. The new litter, it will be remembered, had been requested by Army Air Forces in place of the straight steel.

In order to understand the rather unusual situation which existed in April, 1943, when the first procurement order for the straight wood litter was placed, it is necessary to digress for a moment and examine certain changes that had taken place since the outbreak of war in Medical Department policy with regard to litter development costs. These changes, it will be seen presently, had an extremely important effect on the competitive bidding which took place in the case now under discussion.

A study of Medical Department correspondence as far back as 1939 indicates that, prior to United States entry into the war, it was not customary for the Medical Department to make monetary payment for litter development work performed by private industry. Throughout this period, letters from The Surgeon General's Office to individual manufacturers routinely contained the statement that it was to be understood that any experimental work undertaken would be at the expense of the manufacturer, and without any cost or obligation whatever on the part of the Government.

As we have already seen in preceding portions of this study, during the latter part of 1941 and the whole of 1942 that policy was modified slightly to permit Medical Department requisition of sample poles or litters at a nominal price. In these instances, payment to any one manufacturer seldom exceeded \$10.00 or some comparably modest figure. In 1943, however, a more drastic change in development cost policy was initiated. The new approach was set forth with clarity in Procurement Regulation Number 2, dated 26 March 1943.

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In placing contracts for new articles developed by a manufacturer for War Department use, the following principles will be observed:

1. In general a substantial proportion of the initial orders for a new article should be placed with the manufacturer who developed it. Enough of the volume should be placed with other qualified producers, however, to develop at least one other experience source; except in unusual cases this should be a growing production order and not a limited quantity educational order.
2. When the originating manufacturer demands a price for the item substantially higher than the price for which it can be secured elsewhere, or will require substantially more facilities than some other producer in order to get into production, or is already heavily loaded with orders, and the article can be readily made by one or more other producers, the contracts for the article shall be placed with such producers. In such cases the originating manufacturer should be fairly paid for his development work as such.⁶⁵

With the above facts in mind, we may now proceed to an examination of the somewhat unusual procurement situation which developed with regard to the straight wood litter. In a letter to The Surgeon General's Office, dated 12 January 1943, Mikar Specialties Company (Division of National Store Fixture Company; Baltimore, Maryland), designer and originating manufacturer of the new laminated litter, stated its position regarding production costs as follows:

In order to price these litters in line with your present procurement figures, we wish to emphasize the fact that this can only be done when the poles themselves are manufactured on a mass production basis, and a complete litter assembled on the same premises, thus eliminating unnecessary bulk material shipments and their costs.

According to specifications as completed, or about to be completed, under the direction of Col. Quinnell at Carlisle Barracks, we are ready to offer production on a contract for 150,000 litters at the rate of 1,000 per day, and on a contract for 250,000 litters, 2,000 per day.⁶⁶

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In short, unless an over-all procurement order was placed, calling for an extremely large quantity of complete litters, this company could not be considered a bidder at the price range desired by the Medical Department. That development expenditures would be added to normal operating overhead in arriving at estimated production cost of the new litter was indicated in a later communication, dated 30 March 1943. In reply to a request from the New York Medical Depot that the company fill in the negotiation form pertaining to the experimental litters which it had supplied to the Medical Department, Mikar Specialties Company offered this explanation:

We have been holding open this negotiation with the thought in mind that our development costs could be included in a negotiated contract with the Medical Department as was proposed some time ago, and we would be glad to follow that procedure.

In the event that the negotiation for quantity procurement of litters involving our laminated wood pole cannot be effected, we propose to and will be glad to fill in the subject negotiation form to correspond to our full development costs.⁶⁷

The procurement order which was finally placed by the Medical Department was, in terms of the above expectations, disappointingly small. Only 5,363 litters were involved in the contract negotiations which took place in April, 1943. As a consequence, Mikar Specialties Company was decisively underbid, and the contract for the initial production of the new straight pole litter was, therefore, awarded to another manufacturer.⁶⁸ Mikar Specialties Company had, of course, included development as well as production costs in its final estimate. The extent to which the former item had inflated the company's bid can be readily seen when we examine the itemized bill for development costs alone, which the company submitted to The Surgeon General's Office on 6 June 1943. Costs were segregated into two chronological periods, corresponding to the periods during which the company had developed: (1) the straight wood pole; and (2) a folding wood pole (discussed in Chapter III). Development costs from 2 November 1942 to 2 January 1943, the period which most concerns us here, were listed at \$9,838.52. Total claims, covering both litter items, amounted to \$34,947.10.⁶⁹ These were remarkable figures compared to the sums hitherto spent by the Medical Department for experimental work by private industry.

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Although considerable controversy ensued between the Procurement Division of The Surgeon General's Office and Mikar Specialties Company over the above claims, a settlement was finally reached.⁷⁰ Under the circumstances these discussions might conceivably have resulted in the withdrawal of this key manufacturer from the field of litter production, thus seriously endangering future procurement of the laminated wood litter. This, however, did not occur. The company was not only subsequently invited to bid on other litter production, but through its own representatives the company continued to solicit invitations from the Medical Department on all items it was equipped to manufacture.⁷¹

We now come to our final question. Had neither aluminum nor carbon steel been available in 1943, were the sources of supply of the laminated straight pole litter (even assuming Mikar Specialties Company remained in the field as an active bidder) adequate from a mass production standpoint? On this issue, opinion within the Medical Department was at the time sharply divided. Research engineers in the Technical Division of The Surgeon General's Office contended that sources of supply, though limited, were sufficient for large scale procurement.⁷² On the other hand, authorities in the Supply Service of The Surgeon General's Office, who had supervised negotiations for the initial procurement of the item, considered available sources of supply to be so inadequate that, in June 1944, a definite attempt was made to discourage further procurement of the item in any quantity.

In view of the fact that Item 99368 Litter, Straight, Wood, M-1943, Pole, (a component of Item 99366 Litter, Straight, Wood, M-1943) is difficult and complicated to manufacture, requiring a very high quality of wood, and lamination of that wood in long length, procurement is next to impossible...In view of the above, it is recommended that item 99368 and all indented items thereunder be classified limited standard.⁷³

The above recommendation, it should be noted, was never enacted by the Medical Department. Instead, with the return of aluminum to the active list, the laminated wood straight pole litter was subsequently reclassified in June, 1945, to Substitute Standard. This action was taken by the Medical Department Technical Committee, with two representatives of the Supply Service present.⁷⁴ Apparently at this later date, whether through entry of other manufacturers into the field or due to some other cause, the question of sufficiency of supply sources was no longer a serious point of contention. Parenthetically it may be observed that the straight wood litter was never again placed under procure-

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ment after the initial production order of 24 April 1943.

C. Conclusion.

Had the carbon steel shortage developed as anticipated, and had aluminum not immediately become available in so timely a fashion, it can be seen from the above discussion that there is still some lingering question as to whether, in 1943 and 1944, the new straight wood litter would have effectively filled the breach. Such a situation, it is evident, was fraught with considerable danger, not only for the Medical Department, but for the whole system of casualty evacuation as well.

With these possibilities in mind, it is apparent that the administrative procedures outlined in AR 850-25 had practical value. That regulation had prescribed that, prior to formal standardization, detailed information relative to sources of supply and production costs be prepared by the technical service concerned and forwarded to higher authority for review and final approval. Had this been done in the present instance, it would have been necessary to obtain production cost figures in advance from Hilar Specialties Company. Then, had these costs been considered excessive, the question of the adequacy of the remaining sources of supply would have immediately presented itself. In short, any official disagreement regarding the procurability of the straight wood litter would have necessarily been resolved before standardization could have taken place.

There is no indication from the data at hand that the straight wood litter was processed according to these particular provisions of AR 850-25. Instead, the new litter appears to have been simply added directly to the Medical Supply Catalog as a standard item. In view of subsequent developments (including the hypothetical dangers considered above), the wisdom of standardizing Medical Department equipment items merely by publication of supply catalog change notices would seem to be open to question.

VIII. Evaluation.

A. The Race Against Time.

The race against time, as it turned out, was illusory. Not only did the anticipated shortage in carbon steel fail to develop, but, on 16 August 1943, aluminum was again made available in quantity to the Medical Department.

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However, at least in certain respects, research and development personnel had made a good showing. Less than four months after this second phase of Development Project, F-11 had been initiated, a laminated wood pole had been designed and fabricated which was sturdy enough to withstand extensive field testing, and which had been officially approved by the Medical Department Equipment Laboratory as a satisfactory substitute for the carbon steel pole. However, the procurement side of the picture, especially from a time standpoint, was less favorable. The initial production contract was not awarded until 24 April 1943, nearly four months after final specifications had been prepared and, although only a small quantity order was involved, delivery was not completed until 13 September 1943.⁷⁵ In short, from the time development work was instituted until the initial procurement order was received in full by supply depots, an entire calendar year had elapsed.

B. The Straight Wood Litter versus The Ash Pole Litter.

Compared, component for component, the straight wood litter was clearly superior to the ash pole litter of World War I. To begin with, the new litter was equipped with the standard pressed steel undercarriage which, as we have already seen in a previous section, had long since supplanted the cast iron running gear of the World War I model. Secondly, the 1943 litter was equipped with the slip-on type of canvas cover which had been preferred over tacked-on canvas ever since its introduction in 1935. Thirdly, the laminated wood poles of the new litter, which had carefully been designed for use both with the pressed steel undercarriage and the slip-on canvas cover, were not only sufficiently rigid and sturdy for field use, but were lighter in weight than the solid straight grain ash poles. Finally, and this fact conclusively indicates Medical Department preference, on 31 July 1943, the ash pole litter was formally reclassified to Limited Standard.⁷⁶

C. The Straight Wood Litter versus The Straight Steel Litter.

The straight wood litter and the straight steel litter had several points of similarity. Both were equipped with pressed steel undercarriages, and both made use of the slip-on type of litter cover. To this extent the new laminated model was merely an imitation of the earlier design. The chief difference between the two litters lay in the design and construction of the side poles. Here, in terms of strength, rigidity, durability, and ease of maintenance, the carbon steel poles with their special wooden handle inserts were regarded by the Medical Department Equipment Laboratory as preferable to

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the laminated wood poles with their turned, integral handles.⁷⁷ For these reasons, together with the fact that the anticipated shortage in carbon steel had not materialized, the straight steel litter continued under heavy procurement even after the development of the new straight wood litter.

In terms of weight, however, the wood poles did possess a decided advantage. It was this factor which had led the Army Air Forces to request that the laminated wood litter be substituted for the steel litter as standard equipment for air evacuation. And it was this factor that ultimately led to a shift in preference on the part of the Medical Department itself. After two years of wartime service, the steel litter was no longer regarded as superior to the wood litter. Its heaviness was too great a disadvantage so far as ground force evacuation was concerned. Accordingly, when a general reclassification of Army litters took place on 25 June 1945, the steel litter was dropped to Limited Standard while the laminated wood model was given the preferable listing of Substitute Standard.⁷⁸

D. The Straight Wood Litter versus The Straight Aluminum Litter.

As in the case of the steel litter, in many respects the wood and aluminum litters were identical. Both were equipped with the standard pressed steel undercarriage and the slip-on canvas cover. Both sets of poles were of approximately the same dimension. The chief difference lay in the construction of these side poles, and here the superiority of the straight aluminum litter was immediately evident. The aluminum tubes were stronger, more rigid, more durable and, because of their removable handle inserts, easier to maintain in the field. Finally, in contrast to carbon steel, aluminum was as light as laminated wood. Both litters weighed approximately 17 pounds, so the straight wood model no longer possessed a payload advantage in airplane evacuation. It is not surprising to learn, therefore, that with the removal of aluminum from the critical list, no further procurement of the new laminated litter was attempted. In the general revision of litter classifications in June, 1945, the aluminum model was the only straight pole litter to receive the top listing of Standard.⁷⁹

E. Procurability of The Straight Wood Litter.

No final evaluation of the straight wood litter would be complete without some reference to the factor of procurability. While the Medical Department in 1945 reclassified this item to Substitute Standard rather than Limited Standard, indicating that at this later date production sources were

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considered adequate, the fact remains that in 1943 and 1944 the question of procurability was a subject of genuine controversy within the Medical Department. Consequently any judgment as to the probable value of the straight wood litter in these earlier years--when it might have been urgently needed as a substitute for both the aluminum and steel litters--depends entirely upon which of two conflicting official views was the correct one.

If, in the summer of 1943, the straight wood litter was really procurable in quantity and without excessive cost to the Medical Department, then the experimental result of this second phase of Development Project, F-11 can be very favorably regarded. If, on the other hand, supply sources were in fact incapable of meeting the production demands that would have been created by a critical shortage of both carbon steel and aluminum, then the immediate military value of the product of this second investigation is open to question.

IX. Termination of Development Project, F-11.

With carbon steel still available in quantity, and with aluminum now removed from the War Department list of critical materials, further experimentation in substitute materials for the straight pole litter was unnecessary. Consequently, on 26 October 1943, the Medical Department Equipment Laboratory forwarded to The Surgeon General's Office a formal statement of satisfactory completion of Development Project, F-11.⁸⁰ Less than a week later, on 1 November 1943, recommendation for discontinuance of this project was concurred in by the subcommittee of the Medical Department Technical Committee.⁸¹ On the following day, official notice was given by The Surgeon General's Office that Development Project, F-11 should henceforth be dropped from the monthly progress reports of the Equipment Laboratory.⁸²

X. Conclusion.

Now that the 2½-year history of Development Project, F-11 has been completed, what general conclusions can be drawn from the data that has been presented? For example, what major advances were made in litter design and construction? How did these contributions compare with the structural modifications introduced in 1916 and 1935? What difficulties were encountered in this investigation of substitute materials? Were these difficulties recognized by the Medical Department? What action, if any, was ultimately taken to prevent their recurrence?

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A. Contributions to Straight Pole Litter Development.

Table II, shown on the following page, indicates certain of the major changes that took place in litter design and construction from 1916 to 1943. By glancing through the various sections of the table, it will be seen that the year 1935 was outstanding in number of changes introduced. Comparing the new straight aluminum litter, which was developed in that year, with its 1916 predecessor, it will be noted that thoroughgoing modifications were made in every important litter feature.

Weight was reduced by 5½ pounds, aluminum was substituted for straight grained ash wood in the construction of the side poles, pole length was shortened by 13 inches to accommodate the new removable wooden handle inserts which replaced the old integral wooden handles of the World War I model. Smaller dimension aluminum tubing replaced the relatively thick, rectangular-shaped ash pole. Improved design, and the substitution of cast aluminum for cast iron, reduced undercarriage weight by more than 5 pounds. In place of the cumbersome tacked-on canvas cover of the 1916 litter, hem loops were devised to produce a readily adjustable slip-on cover.

Many of the foregoing improvements, moreover, can be regarded as lasting contributions to straight pole litter development. The duraluminum side pole, wooden handle inserts, slip-on canvas, and basic undercarriage design of the 1935 model strongly influenced all subsequent litter research and remain today, with only minor alteration, important elements in Medical Department litter specifications. Because of the magnitude of 1935 accomplishments, the advances made under Development Project, F-11 may at first glance appear somewhat meager. However, on closer examination it will be seen that the long-term results of these later years of research activity were far from negligible.

In the first place, a carbon steel pole was developed in 1942 which proved to be a remarkably satisfactory expedient for use during periods when aluminum was not available. From 1942 to 1945, this steel pole was procured in greater quantity than any pole in American litter history. Secondly, in 1943, a laminated wood pole was developed which was especially useful in air evacuation where lightness of weight was essential. While never procured in quantity, this pole stood up well under combat conditions and, by its demonstration of laminated wood possibilities, had a direct influence on the later successful development of a double folding laminated wood pole which is today an outstanding Medical Department item.⁸³

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Although, after its return to the "available" list in August, 1943, aluminum once again became the material of choice for straight pole litter construction, the two developments mentioned above had, nevertheless, genuine long-term significance. With carbon steel and laminated wood as well as aluminum to choose from, never again would an unexpected critical shortage find the Medical Department as unprepared as it was in 1941.

Perhaps, however, the most outstanding contribution of Development Project, F-11 was in the field of undercarriage construction. A new stirrup and spreader bar assembly was produced in 1941 which, although similar in design to the 1935 model, was constructed of extruded instead of cast aluminum. This new assembly was lighter in weight, sturdier, and much more readily procurable than the cast aluminum unit. Because of the impending aluminum shortage, however, research investigation was continued.

As a result, in 1942 a pressed steel undercarriage was evolved which was soon regarded as superior to both the cast and extruded aluminum assemblies. Some time later, a universal undercarriage was designed, adapting this pressed steel unit to all straight pole litters used by the Medical Department. Parenthetically it may be observed that, since the termination of Development Project, F-11, a new and improved type of extruded aluminum assembly has been produced which is expected eventually to replace pressed steel. Even this new development, however, owed much to the experimentation with extruded aluminum that was initiated in 1941.⁸⁴

B. The Development of Testing Procedures.

According to the provisions of AR 850-25, newly developed items of equipment should ordinarily be subjected to both engineering and service tests before being accepted for standardization. How well did the Medical Department discharge these obligations during the course of Development Project, F-11? What trends, if any, can be discerned? To what extent has current Medical Department practice been directed toward remedying the defects noted in these earlier years?

The evolution of field testing procedures falls roughly into two periods. During the first period, which coincides with the development of the straight steel litter, reporting policies were fairly elaborate. As the preceding historical account has shown, the typical reporting procedure during 1941 and the early part of 1942 was:

(1) issuance of a formal, written request from the Medical Department Equipment Laboratory to the 32nd Medical Bat-

EVOLUTION OF THE STRAIGHT POLE LITTER (1916-1943)

Explanation of Symbols.

- I. The Ash Pole Litter (1916)
- II. The Straight Aluminum Litter (1935)
- III. The Straight Aluminum Litter (1941)
- IV. The Straight Steel Litter (1942)
- V. The Straight Wood Litter (1943)
- VI. The Straight Aluminum Litter (1943)

1. Litter Weight.

I.	22.00 lbs.
II.	15.50 lbs.
III.	15.10 lbs.
IV.	22.00 lbs.
V.	17.00 lbs.
VI.	17.00 lbs.

2. Litter Poles.

Construction	Length	Shape and Thickness	Handles
I. Straight-grained ash	90 in.	rectangular; 2 x 1-1/2 in.	integral; wood.
II. Duraluminum tubing	77 in.	circular; 1.54 OD*	inserts; wood.
III. Duraluminum tubing	77 in.	circular; 1.54 OD	inserts; wood.
IV. Carbon steel tubing	77 in.	circular; 1.25 OD	inserts; wood.
V. 6-ply laminated birch	90 in.	square; rounded edges; 1-1/2 diameter	integral; wood.
VI. Duraluminum tubing	77 in.	circular; 1.54 OD	inserts; wood.

3. Undercarriage.

	Construction	Weight (per litter)
I.	Cast iron	10.00 lbs.
II.	Cast aluminum	4.56 lbs.
III.	Extruded aluminum	4.16 lbs.
IV.	Pressed steel	7.00 lbs.
V.	Pressed steel	7.00 lbs.
VI.	Pressed steel	7.00 lbs.

4. Litter Cover.

I.	Tacked-on canvas
II.	Slip-on canvas
III.	Slip-on canvas
IV.	Slip-on canvas
V.	Slip-on canvas
VI.	Slip-on canvas

*Outside diameter.

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talion to subject a given item to certain specified field tests; (2) submission of a detailed test report by the 32nd Medical Battalion to the Medical Department Equipment Laboratory; (3) forwarding of a final, comprehensive report by either the Medical Department Board or the Medical Department Equipment Laboratory to The Surgeon General's Office for review and final action.

There were three main advantages to this somewhat complex system of formal reporting. First, these detailed reports provided an adequate basis for intelligent review by The Surgeon General's Office, as well as a check on the performance of the 32nd Medical Battalion and the Medical Department Equipment Laboratory. Secondly, in those instances where, in addition to formal recommendations, specific suggestions were included in these reports for the improvement of an item, manufacturers were given something tangible to work on, and were thus able to focus their efforts more efficiently on the problem at hand. Finally, these reports afford us today our only recorded information as to the individual tests employed, the manner in which they were executed, and the changes in testing procedure that were introduced in these early years of the war.

In contrast to the highly organized procedures described above, reporting policy during the second period covered by this study, which extended from September, 1942, through February, 1943, exhibits no clear or uniform pattern. Judging from the data at hand, the Medical Department Equipment Laboratory abandoned altogether its practice of issuing detailed testing instructions to the 32nd Medical Battalion during this latter period. Furthermore, in only one instance is there evidence of the preparation by the testing agency of a comprehensive written report of field test results. As would be expected, these omissions resulted in a decided lowering of quality of the final Laboratory reports to The Surgeon General's Office. In many of these reports it can only be assumed that extensive field tests were conducted. In others, the recorded test results were too imprecisely expressed to permit a sound technical appraisal and review of the recommendations made. In one instance it appears that no formal report was submitted to The Surgeon General's Office, field test results having been instead conveyed directly to the manufacturer by letter.⁸⁵

Since our knowledge of testing procedures is so closely related to methods of reporting, it is not surprising that the trend in actual field testing resembles to a marked degree the pattern described above. Beginning in the summer of 1941, experimental straight pole litters

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were subjected simply to a short series of very mild, more or less improvised service tests. With the passage of time, however, these field tests became progressively more comprehensive and more rugged. By the close of 1941, a highly systematized and standardized testing procedure had been evolved, simulating with remarkable fidelity actual combat handling of the litter. The year, 1942, on the other hand, witnessed a downward trend in scientific field testing. In the light of recorded data, comprehensive testing procedures seem to have been only sporadically and partially applied and, in some cases, completely omitted. Under such conditions, it is evident that there could be less real assurance as to the future serviceability of any newly developed item.

As for engineering tests there appears to have been, during the period covered by this account, scarcely any regularized procedure. Judging from the formal reports submitted to The Surgeon General's Office, separate engineering tests were not conducted by the Equipment Laboratory. Occasionally, as in the cases of Republic Steel Corporation and Hermsdorf Fixture Manufacturing Company, certain rigidity tests were independently and voluntarily performed by contributing manufacturers. At times these results were incorporated into final Medical Department reports; often they were omitted. In the latter part of 1942, however, a new procedural practice was introduced. Newly developed plywood and laminated wood litter poles were forwarded to the Static Test Laboratory at Wright Field for engineering test. These test reports were then reviewed before a final decision as to standardization was reached by The Surgeon General's Office.

That the Medical Department has come to recognize more and more the importance of engineering tests, and has sought to continue the trend which was initiated toward the close of 1942, is indicated by the altogether new approach that has been adopted in current litter projects. The 1945 investigations of the straight pole litter have included a genuine attempt to test and analyze the physical properties of the metal under consideration. Since it is felt that the Equipment Laboratory at present lacks the facilities needed for thoroughgoing engineering tests, the cooperation of large manufacturers adequately equipped for the task has been enlisted.

C. Problems of Administrative Coordination.

It has already been noted how, on several occasions, the War Production Board extended its jurisdiction over Medical Department research and development well beyond the usual limits of conservation of critical materials and the issuance

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of priorities for experimental purposes. In one instance, the War Production Board in effect initiated an actual limited production contract, and then proceeded to exercise supervisory control over the development work that followed. This problem, as we shall see in a subsequent chapter, largely disappeared after the establishment, in the Commerce Department, of the National Inventor's Council. Originally designed to serve as a clearing house for unsolicited ideas, blueprints, and pilot models submitted by individuals to the Federal Government, this organization eventually came to be used also as a means of discouraging the assumption of research and development functions by such independent agencies as the War Production Board. By referring these agencies to the National Inventors Council as the proper channel for clearance of their research ideas, the Medical Department was able to eliminate much jurisdictional overlapping with its consequent breakdown in administrative coordination.

It has been observed on numerous occasions how a lack of proper coordination between The Surgeon General's Office and the Medical Department Equipment Laboratory resulted in considerable duplication of effort and unnecessary added expense to the private manufacturer. This deficiency was subsequently recognized by the Medical Department and, in the latter part of 1944, a system of liaison visits between these two agencies was established on a bi-weekly basis.⁸⁶ On 3 February 1945, the visits were put on a weekly basis, and representatives were required to prepare itemized reports of conferences held and agreements reached.⁸⁷ This new procedure has served to eliminate to a large extent the parallel action which characterized so many of the joint activities of these agencies during 1941 and 1942.

Finally, it has been pointed out throughout the preceding sections how the failure to conform to the procedures outlined in AR 850-25 could affect research and development results. In the case of Mikar Specialties Company we have seen, for example, how potentially serious production problems may result simply from a faulty administration of standardization procedures. These procedural weaknesses were likewise recognized and dealt with effectively by the Medical Department in later years. Before the close of 1943, as a result of concrete proposals made by research and development officials in The Surgeon General's Office, steps had been taken to insure conformance with the provisions of AR 850-25. With the establishment, in February, 1944, of the Technical Division it can be said that the initiation and termination of Medical Department development projects, as well as the standardization of Medical Department items, were thereafter carried out in close conformance with Army Regulations.

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D. The Evolution of Development Cost Policy.

From 1939 until the latter part of 1941, the Medical Department followed the policy of allowing no monetary payment for development work performed by private industry. This attitude was subsequently modified to permit the requisitioning, at a nominal figure, of sample experimental items. By the early part of 1943, however, Medical Department policy was further liberalized to conform to the latest Procurement Regulations.

Under this new system, the manufacturer credited with successful development of an item was permitted to add development cost to production cost in arriving at a final bid for initial production of the item. Unless this bid was "substantially higher" than competing bids, the contract for the major portion of this initial production was to be awarded to the "originating" manufacturer. If, on the other hand, this bid was substantially higher than other bids, the production contract would be awarded elsewhere, and the originating manufacturer would be "fairly paid" for his development work as such.⁸⁸

Some of the practical difficulties which could arise from application of this procurement regulation were vividly illustrated in the case of Mikar Specialties Company. The lessons learned from this experience were at least two in number: (1) The inflation of bids for initial production contracts by the inclusion of development costs, tended to eliminate the originating manufacturer from effective bidding competition unless development costs were very conservatively estimated. Thus, not only might the manufacturer most familiar with an item be, in effect, barred from its production, but by the elimination of this manufacturer sources of supply could be seriously narrowed. (2) Negotiation regarding development cost would not begin until the manufacturer had actually failed to obtain an initial production contract. Then the disgruntled manufacturer would be asked to submit a bill covering his development expenses. This, it will be appreciated, was scarcely the ideal atmosphere for compromise.

These two problems, both of which were of a recurring nature, were eventually solved by the Medical Department in the early part of 1944. At that time a policy of advance negotiation of development contracts was instituted. Under this new system, development work was carefully outlined in advance, and a specific cost figure agreed upon. Since development costs were thus determined before the project had even begun, and were separated by contract from later production questions, inflated production bids were no longer necessary. Thus, not only might development costs be kept within a more manageable limit, but the competitive element could be restored in industrial bidding for Medical Department requirements.

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FOOTNOTES TO CHAPTER II

- ¹ Heflebower, op. cit., pp. 1-10. The detailed litter descriptions which follow were obtained from this historical account.
- ² Ibid., p. 2.
- ³ Heflebower, op. cit., p. 3.
- ⁴ Heflebower, op. cit., p. 6.
- ⁵ Ibid., p. 6.
- ⁶ See Table I, following p. 16.
- ⁷ Ltr. to The Commandant, M.F.S.S., fr. S.G.O., 26 Feb. 1923 (M.D.E.L.).
- ⁸ Heflebower, op. cit., p. 6.
- ⁹ McKinney, G. L., Col., M.C., U.S.A., "Some Recent Activities and Developments at the Medical Department Equipment Laboratory," The Army Medical Bulletin No. 37, Oct. 1936, p. 45.
- ¹⁰ Ltr. to S.G.O., fr. M.D.E.L., 17 Jul. 1941; subject: "Litter, Substitute for Standard" (M.D.E.L.).
- ¹¹ Ibid., p. 2.
- ¹² 4th Ind. to N.Y. Medical Depot, fr. S.G.O., 19 Dec. 1941; basic: Ltr. to CG, Carlisle Barracks, Pa., fr. N.Y. Medical Depot, 10 Nov. 1941; subject: "Medical Dept. Tentative Specification No. 1416-A" (A.M.R. & D. Bd.).
- ¹³ Ltr. to S.G.O., fr. M.D.E.L., 17 Jul. 1941; subject: "Litter, Substitute for Standard," p. 2 (M.D.E.L.).
- ¹⁴ Memo. to Office of Production Management, fr. S.G.O., 8 Apr. 1941; subjects: "Zimmer Mfg. Co." (A.M.R. & D. Bd.).
- ¹⁵ Conservation Directive No. 14, "Conservation of Aluminum," Office of Under Secy. of War, 12 Jan. 1942.

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16 AR 850-25, Sec. 10-d, 23 Jul. 1936.

17 Medical Department Research Program, Fiscal Year 1941, 3 Apr. 1941, CONFIDENTIAL, p. 43 (Rec. Rm., S.G.O. 700.2-1).
Extracted in clear.

18 AR 850-25, Sec. 5, 23 Jul. 1936.

19 Minutes of Meeting of Medical Department Technical Committee (hereafter cited as Min. of M.D.T.C.), 28 Nov. 1940 and 17 Mar. 1941, respectively (Hist. Div., S.G.O.).

20 Medical Department Research Program, Fiscal Year 1941, 3 Apr. 1941, CONFIDENTIAL, p. 43 (Rec. Rm., S.G.O. 700.2-1).
Extracted in clear.

21 Ltr. of transmittal to T.A.G., fr. S.G.O., 3 Apr. 1941;
subject: "Medical Department Research Program" (Rec. Rm., S.G.O. 700.2-1).

22 1st Ind. to S.G.O., fr. A.G.O., 9 Apr. 1941; basic: see n. 21 (Rec. Rm., S.G.O. 700.2-1).

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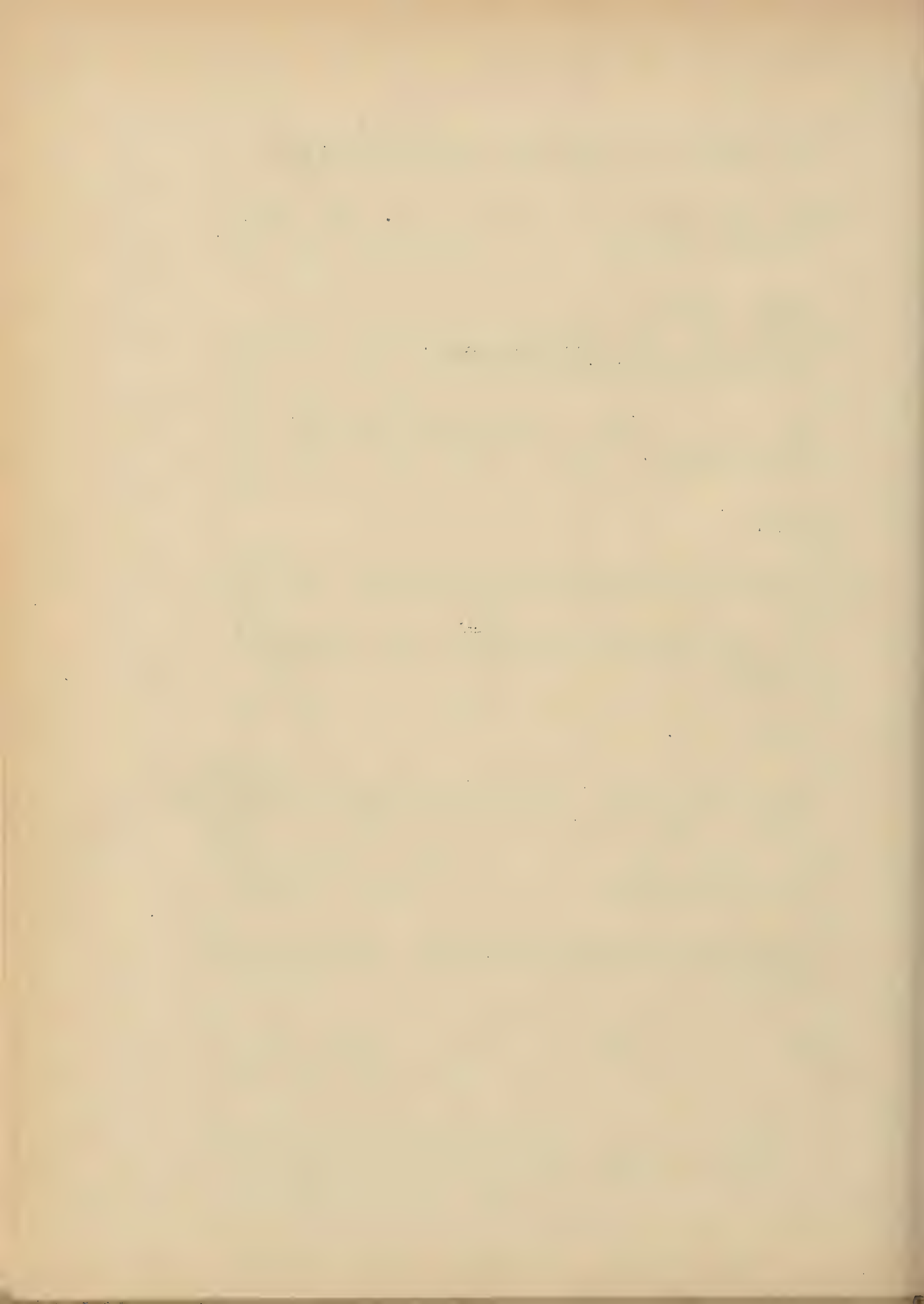
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CHAPTER III

THE FOLDING POLE LITTER

I. Introduction.

A. The Aerial Evacuation of Casualties.¹

The evacuation of sick and wounded by ground troops, in which the Army straight pole litter has played such a key role, dates back to the earliest weeks of the Revolutionary War. Air evacuation, on the other hand, is virtually a contemporary development. Even during World War I, the possibilities of adapting aviation to the needs of the medical service were largely unexplored. With the transport and cargo plane still in the blueprint stage, only small, light aircraft were available, and these were used almost exclusively for combat and reconnaissance missions.

During the years 1914-1918, therefore, the possibility of large-scale medical evacuation by air seemed so remote as to border on the visionary. It was not, in fact, until 12 February 1918, that even the elementary need for some sort of medication to be carried in airplanes for emergency treatment was dealt with officially. On that date, a first aid pouch for airplanes was sent to the Chief Surgeon, Aviation Section, from the Surgeon at Rockwell Field; an action which led eventually to the development and perfection of the Kit, First Aid, Aeronautic.

Airplanes had, of course, been used on occasion to carry Army doctors to the scene of air accidents, especially in the continental United States. From this modest beginning as a kind of high-speed taxi for the medical officer, there gradually evolved the far-reaching concept of the airplane as a flying ambulance. One of the earliest instances of an actual adaptation of this kind occurred in February, 1918, when Major Wilson E. Driver, Medical Corps, obtained permission from the commanding officer of the airfield at which he was stationed to convert a small JN4 plane into an airplane ambulance. Three years later, in 1921, the first standard American air ambulance, called the Cox-Kremlin type A-1, especially designed and constructed for practical ambulance service, was delivered and tested between Washington and New York with impressive results.

Even at this comparatively late date, the use of the airplane as a normal method of casualty evacuation had not yet received top military sanction. Aerial evacuation was still

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regarded officially as a last resort, to be used only in cases of life and death emergency where speed was essential. In a memorandum, dated 11 May 1921, and addressed to the Chief Surgeon, the War Department expressed the following opinion regarding evacuation by air; an opinion which typified the attitude during this period not only of military authorities, but of the general public as well.

Referring to recommendation from this office of April 23 that authority be granted for the transfer of patients from the hospital at Mitchel Field, Long Island, New York to the Walter Reed Hospital, Washington, D.C. by airplane, please be advised as follows: In case of accident, the use of airplanes for the transportation of sick and wounded soldiers, when other safer means of transportation is available, could not be justified. The above recommendation therefore is not favorably considered.²

Rapid expansion of the aircraft industry and a great increase in civilian air travel did much, however, to change public opinion with regard to the safety of air transportation, and this in turn had its effect on War Department policy. In 1923, a striking demonstration of air evacuation was staged by the Army for the Shrine convention of that year. Before the close of 1924, far-reaching improvements had been instituted to insure both a safer and more comfortable ride for the patient. The years that followed likewise witnessed steady progress in air ambulance construction and in the techniques of air evacuation, and with these changes military authorities came to adopt a more and more charitable view of the possibilities of this new evacuation method.

With the outbreak of World War II, air evacuation received its first large-scale test under combat conditions. The results speak for themselves. In 1943, according to War Department figures, more than 173,000 sick and wounded patients of United States and Allied forces were evacuated by American military aircraft. In the Mediterranean area, where patients were flown a total of 16,491,266 miles and 131,762 hours, the average flight was 282 miles and the average flying time 2.2 hours. The evacuation route from Guadalcanal in the Solomon Islands was more than 1,000 miles, and the flying time ranged from $4\frac{1}{2}$ to $7\frac{1}{2}$ hours. The number of deaths during flight in 1943, according to statistics prepared by the School of Air Evacuation, was only 11, a rate of .006 per cent, or 6 per 100,000 patient trips.³

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Commenting on this record, Major General David N.W. Grant, the Air Surgeon, concludes:

On the basis of the A.A.F.'s first full year of experience in the air evacuation of war casualties, we conclude that this is the method of choice for the quick, safe, and comfortable transportation of virtually all types of sick and wounded patients. Air evacuation in troop and cargo carriers has solved the logistical problem of casualty evacuation without any addition of vehicular equipment to Medical Corps units, and has contributed considerably to the tactical success of every major land offensive involving American forces. It has reduced the need for hospitalization in forward areas. Its swift and comfortable delivery of the patient to a hospital equipped for definitive medical care places air evacuation in a group with sulfa drugs and blood plasma as one of the three greatest life-saving measures of modern military medicine.⁴

B. The Evolution of the Airplane Litter.⁵

The growth of the air service during the years immediately following the first World War, and particularly the development in the early 'twenties of the airplane ambulance, created an urgent demand for a special type of airplane litter. Accordingly, in 1921, a research investigation was initiated by the Medical Department Equipment Laboratory in collaboration with the medical officers at McCook Aviation Field. In order to standardize components and thereby facilitate use of the new litter by all the services, a working liaison was also established with the United States Navy.

1. The Stokes Litter (1917).

At the conclusion of World War I, three different types of litters were in use by the Medical Department; the Ash Pole, the Trench, and the Stokes. Of these three the Stokes, (see Fig. 8) which had been developed by the United States Navy and was designed especially for use on troop and hospital ships, was selected by the Equipment Laboratory as the most promising working model for the new airplane litter.

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The Stokes litter was, essentially, simply a metal basket shaped to fit the contours of the human body. The upper rail was made of soft steel tubes, welded together and so curved as to form a closed circuit, roughly octagonal in shape. This tubing was held in position by riveted semi-circular steel braces. The entire metal frame was lined with chicken wire, the patient being held securely in the basket thus formed by straps which passed over his chest, hips, and legs. The lining contained a flap opening designed to permit use of a bedpan.

On each side of the septum, which divided the lower end of the basket into two main furrows for the legs of the patient, a movable foot rest was provided. In place of the conventional stirrup assembly, the litter was supported by a kind of rack arrangement. Three straight rods were fitted against the under-part of the semi-circular steel braces, and were held in position on either side of the litter by a transverse rod to which the three protruding ends were fastened. The litter was also equipped with chains for the attachment of splinting material. Finally, around the metal frame several hand grips were provided, which could be used either for manual carry or could be attached to hoisting apparatus.

The Stokes litter possessed several distinct advantages. In the first place, since it was constructed in large part of wire mesh, it was both non-inflammable and easily disinfected. Secondly, by virtue of its hand grips, the litter could be attached by means of a bridle to hoisting apparatus and could thus be loaded or unloaded mechanically, even on small seacraft. With the patient strapped into the basket, he could be hoisted to a vertical position and then raised perpendicularly. Because of this feature the Stokes litter was, at the time, without equal for the evacuation of patients from ship to shore, or for the transportation by rail of fracture cases.

Viewed, however, in the light of its adaptability to air evacuation, the Stokes litter had several serious defects. It was, to begin with, extremely heavy. Over-all weight was 29 pounds, as compared with 22 pounds for the standard straight pole litter. Also, because of the different sized tubing and the numerous welded joints used in its construction, the litter was difficult to manufacture, and the production cost of the item, even when ordered in quantity, was unprecedentedly high. Furthermore, the Stokes model proved to be structurally weak in certain respects. It was found after extended usage that the rivet attachment of the transverse braces to the metal rail at the top of the frame occasionally gave way, so that in using hoisting machinery the litter had to be bridled with

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particular care. Finally, when the litter was supported only at its ends, under a heavy casualty load the sides tended to bow outward and in some instances to buckle.

2. The Metal Litter (1922).

In spite of the above disadvantages, when research work was begun in 1921 to develop the first Army airplane litter, the Stokes design was selected by the Medical Department as offering a more practical starting point than the designs of either the Trench or Ash Pole litters. To understand this decision, it must be remembered that, in terms of riding quality, the small cabin planes which were in use in the early 'twenties were hardly the equal of the huge cargo and transport planes of today. There were definite advantages, therefore, in a basket type of litter which, by affording additional protection both on the sides and the ends, would keep the jostling of the patients at a minimum, thus insuring a safer and more comfortable ride. Moreover, airport facilities for horizontal loading and unloading of litter casualties were far less elaborate in 1921 than they are today. Consequently, it was considered of prime importance that the new litter be so designed that it could be carried at almost any angle with a minimum of discomfort or danger to the patient.

In view of these factors, it is easy to understand why the Medical Department visualized a modified type of basket litter as the most practicable for use in military aircraft. General Roy C. Heflebower, in his historical account of this period, sums up the official attitude as follows:

The need was for a litter somewhat similar to the Stokes, but of lighter weight, greater strength, somewhat shallower in depth, and with the side walls so flared that several litters could be nested in a small space.⁶

Work along these lines was initiated at the Equipment Laboratory in 1921, with the result that a new litter was developed which met with the approval of the Air Corps and the Medical Department, and which it was felt would be equally acceptable to the Navy with a few modifications.

The new airplane litter, called the Metal litter, (see Fig. 9) weighed 19-3/4 pounds, complete with attachment straps. Several features of the Stokes design had been eliminated entirely. The sanitary opening, the rack-like stirrups, and the chain for attaching splinting

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material did not appear in the new model. Other components of the Stokes litter were heavily modified. The chicken wire lining was fastened to a new secondary metal rail and was dropped two inches below the top rail, so that the entire upper rail would be available for the attachment of bridle slings, ropes, supporting hooks, or any other devices which the Air Corps might wish to use to load, unload, and transport the new litter.

Instead of the cumbersome stirrup assembly of the Stokes model, the Metal litter was supported by two longitudinal rods which were integral parts of the litter frame, serving on the under-side as runners and, at the ends, as braces for the two upper rails. In the bottom of the litter, where the upper portions of the patient's body rested, ash slats were inserted to provide added support and to make the litter more comfortable. A septum divided the lower half of the litter into two furrows for the patient's legs to rest in, substantially as in the Stokes design. In addition, five sets of sling straps were provided which were so placed as to hold the patient securely in the litter, especially when being transported in positions other than the horizontal.

Every effort had been made to simplify the construction of the litter as much as possible without sacrificing strength and rigidity. The tubing had been standardized and the number of sizes and bends reduced to a minimum. Even so, there was still a large number of welded joints, and as a result the cost of manufacture was still comparatively high. This objection was partially offset, however, by the fact that the new litter, in addition to being suitable for use in airplanes, was also considered suitable for use in trench warfare and thus could replace not only the Stokes but the Trench litter as well. This substitution did in fact occur, and before the end of 1928 the Army had only two standard types of litters: (1) the Metal, especially adapted for use in airplanes, trench warfare, and on ship-board; and (2) the Ash Pole, which was expected to fill all other needs.

3. The Straight Pole Litter versus The Airplane Litter.

Before proceeding to a discussion of the deficiencies of the Metal litter and the efforts of the Medical Department to develop a new and more satisfactory item for use in air evacuation, it will be well to pause a moment to consider a factor not heretofore discussed but which, in the case of the Airplane litter, was to exert a profound influence on both the substance and direction of all future

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research. This was the factor of Research Priority, which had not until now been a serious concern of litter research and development personnel.

The establishment of certain broad research priorities had been, of course, a practical necessity for the Medical Department Equipment Laboratory since its inception. Faced with the task of developing, improving, and testing all types of medical field equipment, yet having only a small staff and limited research facilities at its disposal, the Laboratory had been forced from the outset to evaluate, in terms of relative urgency, the various projects with which it was confronted.

Until the development and standardization of the Metal litter, however, the establishment of priorities within the litter program itself had not been necessary. From 1860 to 1917, Army litter research had been devoted exclusively to the development of a satisfactory straight pole litter. Now, in 1928, the Medical Department had two standard litters, each of which had been designed to fulfill certain long-term needs. Since it would be possible only under exceptional circumstances for the Equipment Laboratory to work on several different litter projects concurrently and with equal intensity, the question of developmental priorities was of immediate importance.

There was much to be said for granting straight pole litter projects a priority over projects relating solely to the airplane litter. The straight pole litter had been a standard equipment item since 1861. It had been used exclusively for the next 55 years and, even during World War I, it had been procured in far greater quantity than any other Army litter. While it was evident that the airplane was destined to become an increasingly important factor in medical evacuation, it was at the same time difficult to conceive of a type of warfare in which the simple hand carry would not continue to play a major role. In any event, this was the decision of the Medical Department. The straight pole litter was to receive an "A" research priority, while the airplane litter was to be given a "B" classification.⁷ As might be expected, the effect of this priority policy on subsequent airplane litter development was far-reaching.

The immediate result was, of course, simply to produce a time lag in the development of the airplane litter as compared with the straight pole litter. The extent and consistency of this time lag, in the years following 1928, can be illustrated simply by listing chronologically those litters in each of the above categories which were eventually standardized by the Medical Department. The straight aluminum litter was developed in the spring of 1935, while the folding

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aluminum airplane litter was not perfected until December of that year.⁸ The straight steel litter was approved by the Equipment Laboratory in 1942,⁹ but no comparable item was standardized for use in airplanes. In December, 1942, the straight wood litter was tested and approved by the Laboratory.¹⁰ The folding wood litter, however, was not similarly accepted until March, 1943.¹¹

In the 'twenties, and early 'thirties this time factor was of relatively little importance. So long as the Medical Department's two standard litter types were as completely dissimilar as the Ash Pole and Metal litters, independence of investigation and experimentation was assured regardless of the order in which these research projects were undertaken. However, with the introduction in 1935 of an entirely new type of straight pole litter, and with the development later in the same year of an airplane litter based directly on this new design, the time lag described in the preceding paragraph soon became a factor of the utmost importance.

With a high degree of similarity now existing between the straight pole and airplane litters, it was inevitable that the litter with research priority would henceforth become the governing model for development work in both fields. Since straight pole litter projects already had this priority, the scope of airplane litter research was, from this time forward, heavily circumscribed. After 1935, straight pole litter development predetermined not only the over-all design of the airplane litter and the materials to be used in its construction, but even the specific dimensions of its components.

Nevertheless, it would be incorrect to assume that, in the years following 1935, airplane litter research was confined solely to imitative processes. There was still full opportunity for originality in developing those features of the airplane litter which were unique to its type. It was simply that the research work which was conducted in these latter years was of a more highly specialized character than it had been in the past. Energies were now focussed on a single task; the careful exploration of all aspects of the folding principle; from the sectionalizing of side poles to the perfection of hinge arrangements.

The results of this unusual concentration of effort were, as we shall see, impressive. Not only was a folding aluminum litter developed which was a marked improvement over the 1935 model, but in 1943 a double-folding, laminated wood litter was produced, which is still considered to be the most satisfactory folding type litter in use by the Medical Department.¹² Thus, while it is true that the most

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dramatic airplane litter developments occurred in 1935, the years that followed were in no sense barren ones. The achievements of this latter period even compare favorably with those realized from 1935 to 1943 in straight pole litter research.

II. Development Phase (1) (The Folding Aluminum Litter).

A. Initiation of Development Project, F-7.

Although, as we have seen, the Metal litter was much more suitable for Air Corps use than the Stokes Navy litter, it still possessed a number of definite disadvantages. Attention has already been called to the structural weaknesses of the litter and to its intricate design and consequent high cost of manufacture.¹³ There were, in addition, other deficiencies which proved to be equally troublesome. For example, the Metal litter weighed 19- $\frac{1}{2}$ pounds and, even though it could be nested, was still an extremely bulky item. In terms of airplane capacity, this excessive weight and bulk meant that only a comparatively small payload could be accommodated.

Furthermore, because of the complete dissimilarity between the Metal and Ash Pole litters, no interchangeability of parts was possible. This not only posed difficult maintenance problems but also threatened the smooth functioning of the system of property exchange. Either a patient evacuation by air would have to be transferred to a straight pole litter to be further evacuated through ground force facilities, or special arrangements would have to be made for the return of the airplane litter to air force installations. Finally, the Metal litter was not easy to hand-carry. This, of course, made it awkward to use in Air Corps dispensaries and aid stations, to say nothing of ground force installations.

These disadvantages of the Metal litter became all the more glaring as the conditions which had originally necessitated the use of such a litter for airplane evacuation gradually disappeared. For example, one of the chief advantages of the Metal litter had been that it made possible the transporting of a casualty in almost any position, including the vertical.¹⁴ This feature, however, became increasingly less important as airport facilities expanded and horizontal loading and unloading of casualties became more and more the standard practice. Similarly, the additional protection afforded by the Metal litter during actual air transit diminished in importance as, with the increase in size and weight of military aircraft, riding quality of ambulance planes was steadily improved.

In short, by 1932 the time was ripe for a reinvestigation of the whole problem of airplane litter construction and design. More specifically, with research and development activity no longer limited by military requirements to the basket type of litter, it was now possible to consider the feasibility of adapting the straight pole litter to airplane use. Unfortunately, the Ash Pole litter, because of its extreme weight and bulk, offered little promise. However, as we have already seen in the previous chapter, several years prior to 1932, a research project had been established to develop a new straight pole litter to replace the outmoded Ash Pole model.¹⁵ Moreover, by 1932 this project had been virtually completed and, except for minor changes, a new straight aluminum litter was ready for standardization.¹⁶

With the appearance of this promising alternative, the Medical Department decided to launch its attempt at conversion from the basket type of airplane litter. In January, 1932, Development Project, F-7 was formally initiated to explore the possibilities of adapting the new straight pole aluminum litter for Air Corps use.¹⁷ The experimentation that followed was highly productive. By 1935, a folding aluminum litter had been developed which was destined to serve as a model for airplane litter research for more than a decade.

B. The Folding Aluminum Litter.

The folding aluminum litter (see Fig. 10) was the first of the airplane litters to evolve as a direct by-product of straight pole litter research. Developed by the Medical Department Equipment Laboratory in 1935, the new design was patterned in many respects on the specifications of the straight aluminum litter. The folding model measured 90 inches in over-all length, was 22-7/8 inches wide, and weighed only 15-3/4 pounds. The aluminum alloy side poles were 1.54 inches in outside diameter, and were 77 inches long. Pole handles consisted of standard wooden inserts, 6-1/2 inches in length. The stirrups, which were held stationary to the poles by 4 bolts, were 4-1/2 inches high, 4 inches wide, and had bearing surfaces which were 1-1/2 by 3-1/2 inches. In the upper part of each stirrup was a square box or housing into which one end of the spreader bar was fitted. The spreader bars were equipped with the standard hinge, and were curved downward to fit body contour.

The most unique feature of the new airplane litter was that it had been designed to pull apart longitudinally. Each side pole was divided into two sections which were held together at the center by a slip joint. The female half of the pole measured 46 inches (including the handle insert),

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while the male half was 44 inches long with a 2-3/16 inch insert. The slip-on canvas, forming the bed of the litter, was held in place by the 4 stirrup bolts. At the center, the canvas had cut-outs, bound with tape. In folding the litter, the stationary stirrups protruded outward on each side, increasing the lateral width of the collapsed litter by 4-1/2 inches. Even so, the litter could be folded into a package measuring 46-1/4 by 13 by 3-3/4 inches.¹⁸

After having successfully withstood extensive field testing, the new aluminum litter was next subjected to a series of engineering tests. The results of these were equally favorable. Loaded at the center with a 175-pound patient, the litter bowed only 5/16 of an inch. Under a 340-pound load, similarly placed, deflection amounted to only 12/16 of an inch. Finally, loaded with a 175-pound patient, on old canvas, it was found that the litter still provided sufficient clearance between the patient and the ground.¹⁹ At the conclusion of these tests, standardization of the folding aluminum litter was recommended by the Equipment Laboratory and, on 23 March 1937, the new litter was formally added to the Medical Supply Catalog as a standard item.²⁰ Procurement was initiated 13 May 1937 and was continued under the original specifications until October, 1940.²¹

As is apparent from the description which has preceded, the new folding aluminum litter was not, strictly speaking, a folding litter at all. The two sections of its side poles did not swing on a hinge but were simply telescoped in such a way that they could be pulled apart at the center, thus allowing the litter to be collapsed into nearly the same cubic space as if it had been folded on the long axis. This arrangement had certain disadvantages. It was subsequently found, as we shall see shortly, that the slip joint tended to become clogged when used extensively in mud, gravel, or dirt. Moreover, in order to fold or unfold the litter, it was necessary each time to connect or disconnect the pole sections. This was not only an awkward operation, but one that required the efforts of two men. One other disadvantage of the new litter was its stationary stirrup assembly. Since the stirrups were bolted in fixed position to the poles they protruded outside the canvas cover when the litter was folded. This left the stirrups relatively unprotected, and also increased the cubic space needed to store the collapsed litter.

The advantages of the new folding aluminum litter over the old Metal litter, however, were both numerous and decisive. To begin with, since the aluminum side poles were constructed of straight tubing of a single dimension, instead of different-sized tubing with many bends and welded joints,

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the new model was much easier to manufacture, and had a lower production cost. Secondly, because of the high interchangeability of parts between the straight and folding aluminum litters, problems of maintenance and property exchange were greatly simplified. Thirdly, the new litter weighed only 15-3/4 pounds as against 19-3/4 pounds for the Metal litter. In terms of airplane payload, this was a consideration of the first importance. Fourthly, the folding litter occupied much less space when collapsed, and thus could be stored in air ambulances and other planes in much greater quantity than the Metal litter. Finally, since the new airplane litter could be as easily hand-carried as the straight pole litter, it could be used without difficulty at any point in the chain of evacuation and, by the same token, was entirely suitable for ground use by Air Corps dispensaries and aid stations.

C. The Gran Portable Litter.

While the 1935 aluminum litter was the only folding model which was standardized during this first phase of Development Project, F-7, four other folding litters were submitted to the Medical Department during this period which merit at least brief consideration. The first of these, the Gran Portable Litter, is of interest here because it represented an entirely new type of folding litter design. The rejection of this model, however, led to a lengthy and time-consuming controversy between the inventor of the new litter, Doctor Albert G. Gran, and the Medical Department. In a later section we will have occasion to examine this rather tempestuous controversy in some detail, as it involved certain policy questions intimately affecting the conduct of Medical Department research.²²

On 29 March 1939, Doctor Gran demonstrated his portable litter before a group of officers of The Surgeon General's Office and, on the following day, gave a similar demonstration for members of the Medical Department Board at Carlisle Barracks, Pennsylvania.²³ It was decided that the possibilities of the litter were such as to justify thorough test to determine its practicability and, in accordance with this, the inventor agreed to make and deliver without cost to the Government two sample litters for laboratory and field testing.²⁴ Upon receipt, the new litters were service tested by the 1st Medical Regiment at Carlisle Barracks, Pennsylvania, both individually and in comparison with the new standard aluminum pole litters, folding and straight.²⁵ On 24 July 1939, the Medical Department Board rendered its formal report on the test results.²⁶

The Gran litter was "V"-shaped, and consisted of four pieces of iron tubing, held together by four slip joints,

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and so constructed as to form a double incline sloping toward the center. Slip-on canvas covered each incline, and was fastened at the bottom with 2-inch straps fitted with buckles. Iron foot rests were welded at the bottom of the incline. Handles of aluminum were provided, which were ridged longitudinally and moved inward, toward the center. They sloped downward and were only 17 inches apart. The litter had a total of eight different weldings.²⁷

In summarizing its findings, the Medical Department Board listed the following advantages and disadvantages:

Advantages: Without the foot rests and handles, and for certain types of cases, this litter can be used to great advantage, e.g., up and down steep, narrow, winding stairways, loading patients on ordinary transportation and airplanes.

Disadvantages: Are many for use in the military service. Its "V" shape precludes its use for shocked patients as well as for fractures of the legs.

Its weldings are expensive, cannot be repaired in the field, and the litter is patented.

Due to the sag, the patient sits on the cold damp ground or on the bottom of an ambulance.

It can be loaded only in the bottom berths of the field ambulance and requires considerable effort to dress.

The handles are made of metal heavily ridged, therefore are hard on the hands, causing blisters, and in very hot or cold weather will be uncomfortable. They slant downward, are hard to hold, and the slings will inevitably work back against the bearers' hands. Being only seventeen (17) inches apart, the handles are too close for use by a two man litter squad. The handles hit the bearers' hips, and there is not sufficient room for his medical pouches. Since the handles are hinged inward only, the loaded litter increases this inward motion--which increases markedly the bearer's burden by requiring a firm constant grip.

The litter is very flexible, and due to its shape (double incline or "V" shape) there is a decided drag or downward pull on the leading bearer.

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Altogether this litter loaded is a most burdensome, fatigue producing method of litter bearing.²⁸

In conclusion, the Medical Department Board recommended that the Gran litter be rejected for use in the military service, and this recommendation was concurred in by higher authority.²⁹

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D. The Schwichtenberg Litter.

On 6 May 1939, the Surgeon at Wright Field, Dayton, Ohio, forwarded to the Surgeon General's Office a folding steel litter which had been designed and constructed by Captain A. H. Schwichtenberg of the Station Dispensary at Wright Field. It was stated in the accompanying communication that the litter, which had been built in the officer's spare time, had undergone preliminary service tests and appeared to be superior in all respects to the standard type litters then available.³⁰ After inspection by The Surgeon General's Office, the new litter was sent to Carlisle Barracks where, from 2 June to 20 June 1939, it was subjected to a thorough field test by the 1st Medical Regiment.³¹ On 24 June 1939, a formal report of test findings was made by the Medical Department Board.³²

The poles of the Schwichtenberg litter were constructed of tubular steel, 1.25 inches in diameter. The slip-on canvas cover was a one-piece fabric, and was designed with leather bound cut-outs for each of the four stirrups. The cover was supported underneath by two web straps running diagonally, like an elongated "X", from one stirrup to the opposite stirrup at the other end. The stirrups were flat iron, staggered to allow for folding of the side poles, and each end was fastened to the steel tubes. One end was held in a 1-inch slot, the other by a bolt welded to the pole.

The spreader bars were castings and were fastened to the side poles by the same welded bolts as were the stirrups. They curved downward to allow for canvas stretching, and folded in opposite directions to avoid overlapping. The handles of the poles were covered with synthetic rubber which had been cemented on with neoprene cement. With this extra covering, the handles were 1.6 inches in diameter. Instead of a slip joint to hold the two sections in each pole together, the litter was equipped with hinges which were welded to the center of the poles. Folded, the litter formed a compact bundle, 48 x 6 x 7 inches and weighing only 15.5 pounds.³³

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The Schwichtenberg litter, as the final report of the Medical Department Board indicated, offered several advantages over the standard folding aluminum litter. It could be folded and unfolded easily by one man, whereas the standard litter required more effort and, in some instances, additional assistance. Since the stirrups and spreader bars folded inward, the steel litter made a smoother, more compact bundle, which was easier to handle than the folded aluminum model. Furthermore, the hinges of the new litter worked satisfactorily in mud, cinders, and dirt, while the slip joint of the aluminum litter tended to become clogged.

In the view of the Medical Department Board, however, the advantages of the new steel litter were overbalanced by its disadvantages. To begin with, the litter had fourteen weldings which were not only expensive, but could not be repaired in the field. Likewise, the ten leather bindings were expensive and increased production costs. The "X" shaped web support under the canvas appeared to serve no useful purpose, and it was possible for these exposed loops to catch on other equipment or on brush or foliage. Unless handled very carefully, the sharp flange edges of the hinges cut the canvas and, in any case, were a potential danger to litter bearers.

The stirrups, which were shorter and narrower than the standard stirrup, had a tendency to sink into the ground, thus leaving no clearance for the patient. Moreover, due to their lack of a broad and rounded bearing surface, the stirrups had cut into the linoleum covering the floor of the ambulance. The spreader bars hung down lower than standard bars, and were bolted to the stirrups instead of being in a bearing. Consequently, they tended to spread at the bottom, thus placing an increased strain on the entire assembly. The handles of the litter were too large to permit a firm grip under a normal casualty load, and the synthetic rubber covering blistered the bearers' hands, rubbed off, and, it was felt, would wear unevenly and probably crack with age when stored.³⁴

Although, as a result of the recommendations of the Medical Department Board, the Schwichtenberg litter was finally rejected, the inventor had nevertheless introduced certain innovations in folding litter design which were destined to be of long range importance. The first of these was the folding stirrup, which, in contrast to the stationary type, could be rotated inward when the litter was folded. Because of this folding feature, the litter could be collapsed into a more compact and easily handled bundle and, at the same time, the stirrups themselves were better protected since they did not protrude outside the package.

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Even more important was the development of a folding hinge as a substitute for the slip joint of the standard aluminum model. Not only had the new hinge proved to be less subject to clogging than the slip joint assembly, but, as the Medical Department Board pointed out, it greatly simplified the task of folding and unfolding the litter. In order to fold the standard litter, virtual disassembly of the side poles was necessary. Conversely, preparing the collapsed litter for service involved the equally awkward and time-consuming task of connecting the four separated pole sections. With hinged instead of detachable sections, both of these operations were much easier to perform, and, under favorable conditions, required the use of only a single bearer.

Neither of the above innovations, however, was to be immediately adopted. In fact, as we shall see presently, even their eventual incorporation into Medical Department specifications was accomplished only after the most extended discussion. Ironically, the most vigorous opposition came from the Medical Department Equipment Laboratory; the very agency which had been the first to call attention to the possibilities of both the folding stirrup and the folding hinge.

E. The Gold Medal Folding Litter.

The experimental importance of the Gran and Schwichtenberg litters was not confined to the interesting variations in folding litter design which they represented. Equally significant were the materials which had been used in the construction of these new models. In the Gran litter iron tubing had been used instead of aluminum in the construction of the side poles, whereas in the Schwichtenberg model tubular steel had been employed. While, under field testing, neither metal proved to be the equal of aluminum, this in itself was a sufficiently important discovery to indicate the practical value of the comparative examination. Now the Medical Department Equipment Laboratory was to have an opportunity to consider the suitability of an entirely different substance as a possible substitute for aluminum. Like the straight pole litter of 1916, the Gold Medal folding litter had side poles which were constructed of solid straight grain ash wood.

This new folding litter, which had been developed by the Gold Medal Folding Furniture Company of Racine, Wisconsin, was submitted to the Equipment Laboratory in September, 1939.³⁵ Its rectangular ash poles were 90 inches long, and were 1-1/2 by 1-3/4 inches in width and thickness. Each side pole folded at the center on hinges which were riveted from the underneath side of the separate pole sections to overhanging channels on top. Small pins were driven through the

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flanges of the channels and through each of the pole sections about $5/8$ inches from the top of the pole. A small chain was fastened to the two pins protruding on each side, these chains stretching taut when the poles were unfolded for casualty carry, thus holding the litter open. The canvas cover, which had a bound cut-out around each hinge, was attached by tacking to the outer side of each pole.

The spreader bars were straight, instead of being curved downward as in the aluminum model, and were fastened to the side poles by rivets which also held the stirrups in place. As in the case of the Schwichtenberg litter, the stirrups, which were $2-1/2$ inches high and had bearing surfaces measuring $1-3/8$ by 3 inches, rotated inward when the litter was folded. This decreased lateral width of the collapsed litter considerably, so that the Gold Medal litter, when folded, measured $48-5/8$ by 7 by $3-1/2$ inches. Due to their folding feature, however, the stirrups had no box connection with the spreader bars, and thus had a tendency to weakness and internal rotation under the normal casualty load. Over-all weight of the new litter was 21 pounds as against $15-3/4$ pounds for the standard aluminum model.³⁶

The litter was subjected to routine engineering tests with the following results. Under a 175-pound patient load, placed at the center of the litter, a mid-point deflection of $15/16$ of an inch was recorded. Under a patient load of 340 pounds, similarly placed, center deflection amounted to $1-1/16$ of an inch. Due to the shortness of the stirrups and to the new unstretched canvas with which the litter was equipped, insufficient clearance was provided between the bed of the litter and the ground. Loaded with a 175-pound patient, the litter allowed the patient's buttocks to rest on the dry ground. It was felt that, had the test been performed in soft ground or mud, the patient would have been even more exposed to cold and dampness.³⁷

After field testing, the Laboratory listed two advantages of the Gold Metal folding litter over the standard aluminum model: (1) the new litter made a more compact bundle when folded, (2) the poles were made of ash wood which was not a critical item. On the other side of the ledger, the disadvantages noted were numerous. The new litter was $5-1/4$ pounds heavier than the standard model, the five holes drilled in the center of each side pole tended to weaken the litter where the weight was greatest, the stirrups were too short to afford clearance above the ground for the patient, and the straight spreader bars were uncomfortable since they did not fit the contours of the patient's body as it rested on the litter.

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Major criticism was focussed on the hinge and stirrup arrangements. It was found that the canvas cover and the chains and pins that served to hold the litter straight tended to catch in the hinges and under the channels. This not only interfered with opening the litter but, unless considerable care was taken, caused tears in the canvas. As for the stirrups, since they rotated with the movement of the spreader bar in opening, closing, and folding the litter, it was felt that their rotation would cause wearing and eventually weakness in the poles near their ends. It was concluded by the Laboratory that the Gold Medal folding litter in no way met the requirements of the military service as well as the standard folding aluminum litter.³⁸

F. Zimmer Folding Litter.

On 3 April 1940, The Surgeon General's Office informed the Commandant at the Medical Field Service School, Carlisle Barracks, Pennsylvania that a representative of the Zimmer Manufacturing Company of Warsaw, Indiana would soon deliver to the Equipment Laboratory a modification of the Army's standard folding aluminum litter. It was requested that the new litter be subjected to a full field test and that a formal report be rendered covering test results.³⁹ Two days later, the new litter was received by the Laboratory at Carlisle, inspected, and then turned over to the 1st Medical Regiment for extensive testing.⁴⁰

One month later, in a follow-up communication from The Surgeon General's Office, there appeared the first official indication that the Army's standard folding aluminum litter was not holding up as well as had been expected.

This office on 3 April 1940 requested an extensive field test of a modification of our folding aluminum litter as manufactured by the Zimmer Mfg. Co.

There is now under process a purchase of 750 folding litters. Our New York General Depot reports that the standard aluminum folding litter now used at that depot for a sample and demonstration item has not stood up as it should. The personnel at that depot believe we should not purchase more of the present type.

It is desired that a preliminary report on the subject item be forwarded to this office, in order that a decision may be made referable purchase of this item.⁴¹

In view of the fact that the standard folding aluminum litter (1935 model) was no longer regarded as satisfactory

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by Army purchasing officials, the Supply Division was instructed by The Surgeon General's Office to purchase no new lots for the time being.

The present standard folding (telescoping) aluminum litter has not proved entirely satisfactory. For example, folding or opening it when the canvas is wet is extremely difficult and may be impossible. Further, the actual necessity for a folding type litter is very limited, and in fact it can nearly always, if not in all cases, be replaced by the standard litter.

For these reasons it is believed by the Planning and Training Division to be inadvisable to purchase any new lots of folding litters (aluminum) for the time being.

If the folding litter now being tested at Carlisle Barracks proves to be unsatisfactory it will not be adopted.⁴²

It will be recalled that, because of its heavy castings, the original straight aluminum litter had not been procured in great quantity.⁴³ Because of this short supply, together with the fact that the extruded aluminum undercarriage had not yet been perfected, if a straight pole litter were to be substituted for the folding pole model it would have to be the old Ash Pole litter of 1916. This information was conveyed to the Air Corps on 10 June 1940 by the Supply Division of the Surgeon General's Office.

Your attention is invited to basic memorandum which cancels present purchase of subject item (folding aluminum litter).

The folding litter is a component of the crash splint set, and since our stock is now depleted, it will be necessary to substitute a wooden pole litter pending development by Carlisle of a satisfactory folding litter.

Your comment referable this substitution is requested.⁴⁴

On 19 June 1940, the Chief of the Medical Division of the Air Corps replied to the above communication as follows:

It is considered extremely necessary that the Air Corps be furnished a folding litter, because of the difficulties involved in transportation. The litter in question has, as far as known been extremely satisfactory in all Air Corps maneuvers, etc. on which it has been used. If the litter, for reasons unknown to the undersigned, is not considered satisfactory, it is requested that immediate steps be taken toward the development of a suitable folding litter for use in the Air Corps.⁴⁵

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In view of this recommendation by the agency which was the principal user of the folding litter, it was decided by the Medical Department to continue procurement of the standard folding aluminum litter, pending the development of a more generally satisfactory model.⁴⁶ The controversy was, therefore, temporarily ended, but, as we shall see in a later section, two years later the Air Corps was to reverse its stand regarding the suitability of the slip joint and stationary hinge type of folding litter.⁴⁷

Meanwhile, tests had been going forward on the Zimmer modification of the standard folding litter, and on 1 July 1940, the Medical Department Board submitted its formal report on the new litter to The Surgeon General's Office.⁴⁸ The Zimmer litter's most important feature was its unique hinge arrangement for folding the side poles. In other respects, it closely resembled the standard Army design. The new hinge consisted of three main parts: (1) the pole sections themselves, which were the regular aluminum tubing, 1.54 inches in outside diameter, and 0.109 inches in wall thickness; (2) two short pieces of solid aluminum which fit inside the pole sections near their point of juncture, and the ends of which contained a milled slot designed to receive a hinge link; (3) a hinge link, 1-1/4 inches wide, 1/2-inch thick, and about 3 inches long, which fit into the milled slot to which it was fastened by 3/8-inch pins, one for each pole section. The pole sections could, therefore, be revolved (folded) on this hinge link through a 180-degree arc.

In preparing the litter for service, however, it was necessary to unfold the poles and then give them a one-quarter turn before opening the spreader bars—in order to place the flat side of the link hinge parallel to the ground so that it could best support the weight of the loaded litter. This feature proved, under test, to be the most serious drawback to the new litter. If the spreader bars were accidentally opened before giving the quarter-turn to the side pole, the litter was likely to collapse. This, in fact, occurred during the field test, although the litter was being handled by experienced personnel. The broken spreader bar was replaced by a forged steel one, and the litter was packed on a truck for shipment to Texas where the 1st Medical Regiment was to hold maneuvers. Though, according to the Regiment's Commanding Officer, the litter had been most carefully packed, on arrival both braces were found to be broken and further testing was impossible.

The litter was returned to the Equipment Laboratory, where two new spreader bars were made, and the Zimmer litter was once more subjected to careful study and laboratory testing. As a result of this examination and the field experience described above, the Medical Department Board submitted its formal findings as follows:

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a. The subject litter is complicated in construction and, therefore, expensive to build.

b. Certain parts are too fragile and too easily damaged for field use, or parts may be lost. For example, the limiting pins and spreader bars.

c. Mud, sand, snow or ice in the hinge, the stirrup sleeves, or in slots for the limiting pins in all probability would seriously interfere with the operation of the litter at times.

d. If the litter is not properly opened and made ready for extending the spreader bars (that is, the quarter-turn of the poles so as to place the limiting pins in the exact position), one pole is apt to collapse with the patient on it. This is particularly true when the canvas has stretched. To open properly this litter for patient bearing would be difficult under battle conditions especially at night even with trained personnel.

e. The subject litter is more than two (2) pounds heavier than the present folding litter.

f. Its only advantage over the present folding litter is that it can be opened and closed by one person provided it is in good working condition and none of its parts stick, bend, or are caked with mud, snow or ice.⁴⁹

The Medical Department Board, therefore, recommended the rejection of the Zimmer folding litter, and this recommendation was approved, 10 July 1940, by The Surgeon General's Office.⁵⁰

G. Summary of Development Phase I.

Beginning in 1932, the Medical Department turned its attention to the development of a satisfactory substitute for the Metal litter which had been in use by the Air Corps since the termination of World War I, but had now become largely unsuitable for that service's needs. Taking as its model the recently developed straight pole aluminum litter, the Medical Department Equipment Laboratory produced before the close of 1935 a new folding type of airplane litter which was subsequently approved both by the Medical Department and the Air Corps. This litter, which was equipped with standard duraluminum poles and cast aluminum undercarriage, had one outstanding new feature. Its side poles had been sectionalized and attached at the center by means of slip joints, so that the litter could be collapsed into a compact bundle measuring 1380 cubic inches.

While the new folding aluminum litter became a standard catalog item in 1937, the Equipment Laboratory

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continued to seek ways in which the model could be improved. First of all, careful examination was made of various materials other than aluminum which could be used in the construction of the side poles. Iron tubing, tubular steel, and straight grain ash wood were tested successively, and, while none of these materials proved to be the equal of aluminum, valuable information was gained regarding their differing physical properties and their actual performance under field conditions. Secondly, a wide variety of stirrup assemblies, designed to replace the stationary stirrup of the standard litter, was inspected and tested extensively in the field. It was found that a rotating stirrup decreased the lateral width of the litter when folded, thus reducing the cubic space required for storage and shipment. The problem which remained was to develop a folding stirrup which did not also rotate inward under a full casualty load and which did not tend to weaken the side poles at the point of juncture.

Finally, a comprehensive investigation was made of a number of possible alternatives to the slip joint arrangement of the standard folding litter. Welded hinges, riveted hinges with chain reinforcements, and link hinges were all subjected to complete laboratory and field tests. Of these various alternate devices, the link hinge appeared to be the most promising. In its present form, however, this hinge was still unsatisfactory. In order to bring the metal link into proper position to support the full weight of the casualty, it was necessary to give the side poles a one-quarter turn before opening the spreader bars. This procedure was not only awkward but, unless it was followed exactly, the litter could be seriously damaged and might collapse under the patient. Consequently, additional research was required before the link hinge could be accepted as a substitute for the slip joint type of connection.

By the middle of 1940, a new element of urgency had entered the picture. As a result of criticism by the New York General Depot and the Planning and Training Division of The Surgeon General's Office, procurement of the standard folding aluminum litter was suspended. While, upon the insistence of the Medical Division of the Air Corps, authority to purchase this item was soon restored, the Medical Department made it clear that the restoration would only be temporary—"pending the development of a more perfect folding litter."⁵¹ It was, therefore, incumbent upon research and development personnel to produce either an entirely new type of airplane litter or a satisfactory modification of the standard folding model as quickly as possible. Accordingly, the Medical Department provided for formal continuance of Development Project, F-7 during the Fiscal Year, 1941.⁵²

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III. Development Phase (2) (The Folding Wood Litter).

A. Introduction.

Now that the historical background of this project has been traced, we are in a position to consider in somewhat greater detail the current developments with which this study is chiefly concerned. The account which has just preceded, however, affords a convenient yardstick by which the folding litter developments which occurred after 1 July 1940, can be measured. With the earlier information in mind, it is now possible to determine to what extent World War II research in this field was mainly a logical extension of prior experimentation, and in what respects it represented totally new departures.

Before beginning our examination of this second period of Medical Department research, attention should be called to the rather remarkable cycle through which the folding litter passed during these later years. Prior to 1940, it will be remembered, the folding litter had been an almost exclusively Air Corps item. It had been a component of crash splint sets and had been used extensively in air evacuation in place of the 1921 Metal litter, but its use by ground force troops had been negligible. Before the close of 1940, however, the folding litter was being viewed as having somewhat wider possibilities. This first mild broadening of scope is suggested in the Medical Department's research prospectus for the Fiscal Year, 1941, where the aims of Development Project, F-7 were set forth as follows:

To provide an adequate folding litter for use in transporting military patients, which when not occupied, may be folded for more advantageous and economical carriage under certain conditions, such as in airplanes or on pack animals, or in other places requiring shorter length than the standard 90" litter.⁵³

By the early part of 1942, marked changes in military tactics had occurred which soon opened the way for new uses of the folding litter which had been scarcely dreamed of a few years before. In its Monthly Progress Report for February, 1942, the Medical Department Equipment Laboratory listed its current objectives as follows:

Work has been initiated in an effort to develop a folding litter designed to provide more compact folding features and lighter weight. This litter is being designed primarily for use with parachute troops, air-borne infantry, mountain troops, and other specialized units of the Medical Department of the U. S. Army.⁵⁴

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In short, what had originally been designed as an airplane litter, a practically single-function item, had now become a special all-purpose litter, used extensively by ground force troops as well as Air Corps personnel.

By 1945, the cycle had run its full course. Air ambulances were now being so constructed that large doors were provided in the rear of the planes, thus making the operation of loading and unloading casualties virtually as easy as with a motor car ambulance.⁵⁵ As a result of this development, the Army Air Forces formally requested a shift in litter procurement--from the folding pole litter to the standard straight pole litter.⁵⁶ This recommendation was approved and, thus, the Service which had originally been the principal user of the folding litter had now withdrawn from the field completely.

B. Zimmer Manufacturing Company, Warsaw, Indiana.

Returning now to our main narrative, it will be remembered that the first Zimmer folding litter had been rejected by the Medical Department Board on 1 July 1940, and that these findings had been concurred in by The Surgeon General's Office nine days later.⁵⁷ The manufacturer was informed of this decision, and the principal defects of the litter were pointed out. Officials of the Zimmer Manufacturing Company stated that they believed these deficiencies could be corrected and, approximately one month later, a new and improved model (see Fig. 11) was brought to The Surgeon General's Office for inspection. This litter was found to be definitely superior to the first Zimmer model, and it was thought that it might prove to be even a more satisfactory type of folding litter than the one then in use by the Army. Consequently, on 20 August 1940, The Surgeon General's Office requested the Medical Department Board to have the new model subjected to thorough and extensive field testing and to submit a formal report of its findings as soon as possible.⁵⁸

Four days later, the Zimmer modified litter was forwarded by the Equipment Laboratory to one of the post's medical battalions for field testing. The following instructions were issued:

- a. The litter should be tested in comparison with the present standard aluminum pole litter and the present folding litter.
- b. Carries up to 1/2 mile, loaded with patient weighing 175 pounds or more. Particular attention should be given to note if there is any tendency for the hinge joint to open and close when the litter bearers are in step during the carry, and the effect of wear on the hinge joint, as well as damage to the inner edge of the poles at the joint.
- c. Loading and carrying the litter in the standard ambulances. Does the litter tend to bend at the middle when loading ambulances or when passing over obstacles.

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d. A thorough testing in the mud and sand to determine their effect on the hinges and stirrup bearings of the litter.⁵⁹

Before proceeding to a discussion of the field test results, it should be noted that the new Zimmer litter differed from the original model in several important respects. To begin with, the handles of the new type no longer required a one-quarter turn before the spreader bars could be safely opened. As a result, the limiting pins which had formerly been an essential part of the mechanism had now been eliminated entirely. This removed the old danger of shearing off the pins or breaking the spreader bar in forcing the litter open. It further eliminated the possibility of not engaging one or more of the pins, thereby causing the litter to collapse on one side when loaded. Secondly, the new litter had a different stirrup and spreader bar assembly. Although the rotating stirrup principle had been retained, changes had been made both in the design of the stirrup and in the manner in which it was fastened to the side pole. Certain features of the spreader bar were also new. The weight of the entire assembly, however, was 5.44 pounds as against 4.34 pounds for the standard undercarriage.⁶⁰

On 4 October 1940 the Commanding Officer of the testing battalion submitted his findings to the Equipment Laboratory. On the positive side of the ledger it was reported that in ambulance loading and unloading, the performance of both the Zimmer and the standard folding litter had been identical. It was also found that the new litter did not buckle at the middle during loading or unloading operations, or when passing obstacles. Moreover, the link hinge did not tend to open or close when the litter bearers were in step. While it was found that the ease of assembly and disassembly of the two litters was about the same when two persons were employed, it was conceded that the standard folding litter was more difficult for one person to disassemble. Finally, no actual breakdown of any part of the new litter was reported.

On the other hand, in comparison with the standard folding litter the Zimmer model was found to possess a number of disadvantages. The Zimmer litter was 4-1/2 pounds heavier, and occupied 1359 cubic inches as compared with 1155 cubic inches for the standard model. The new litter was regarded as having too many moving parts and exposed bearing surfaces which, it was believed, would not stand up under rough field usage. The Zimmer design called for 12 bolts as against 4 bolts for the regulation model. Furthermore, the stirrups, it was stated, cut into the canvas bed when folded, and also tended to become loose and to wobble with use.

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As for the link hinge, its surfaces were found to be very inaccessible for cleaning and to be exposed when the litter was folded. Constructed of soft aluminum alloy, these surfaces were easily damaged in loading and unloading operations. When open, the litter was awkward for one man to carry as it tended to buckle in the middle. Also, because the cover was designed with square instead of rounded corners around the hinge, the canvas had been torn in two places before the completion of the tests. It was next pointed out that, since the pole sections were hinged together in the Zimmer model, the failure of one section would require replacement of the entire side pole involved. In contrast, the pole sections of the standard litter, being attached by a slip joint, could be individually replaced without difficulty. Finally, it was estimated that the Zimmer litter, because of its many movable parts, would be more expensive to manufacture than the standard model.⁶¹

This information, together with a formal recommendation that the new Zimmer litter be rejected, was forwarded by the Equipment Laboratory to the Medical Department Board on 2 May 1941.⁶² On 4 June 1941, this recommendation was sustained by the Board in its official report to The Surgeon General's Office.⁶³ No documentary evidence has been found, however, to indicate that this decision was ever formally concurred in by The Surgeon General's Office. Instead, the records show that new specifications were drawn up, based directly on the new Zimmer design with its folding stirrup and link hinge, and that before the close of August, 1941, these specifications received official Army designation.⁶⁴ In addition, procurement records indicate that the hinge type of folding litter was soon being purchased in preference to the "pull-apart" model.⁶⁵

When, however, as a result of straight pole litter research, a new pressed steel stirrup and spreader bar assembly was developed in the latter part of 1941, the Zimmer design was officially superseded. After this date, Medical Department specifications for the collapsible aluminum litter called for the original slip joint model with fixed stirrup and the new steel undercarriage.⁶⁶ The matter might have rested there had it not been for the fact that in May, 1942 certain events occurred which led the Air Corps to reopen the case. On 25 March 1942, a request was received by The Surgeon General's Office from Headquarters, Air Service Command, that 75,000 litters (Medical Department Catalog No. 99380) be purchased for the Fiscal Year 1943. Presumably the specifications then in force, which called for the slip joint, fixed stirrup type of folding litter, were to apply.⁶⁷ On 22 May 1942, however, Medical Department procurement officials received the following communication from the Supply Division of the Air Corps.

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On May 18th, a representative of the Zimmer Manufacturing Company was in this office and demonstrated two types of folding litters. The litter recommended is the aluminum litter of the Zimmer type which has a folding joint instead of a slip joint. The reasons for this recommendation are that with a slip joint litter, considerable difficulty will be encountered when the corrosion of these joints begins due to the salt air and moisture where these litters will be used; also, when the canvas becomes damp, and this litter is open, considerable difficulty will be had in breaking the litter for packing.⁶⁸

This request for purchase of the Zimmer type of folding litter instead of the currently standard Carlisle type brought a vigorous reply from the Medical Department Equipment Laboratory.

The Equipment Laboratory does not recommend the procurement of any Zimmer type folding-stirrup collapsible pole litters for the following reasons:

1. This Zimmer litter was previously tested by the Equipment Laboratory and found not suitable for field service; the Medical Department Board concurred in this recommendation.
2. The Zimmer type litter is made almost entirely of aluminum, which is highly strategic.
3. The Zimmer type litter is considerably more expensive to manufacture than the present standard collapsible pole litter.
4. The present collapsible litter is more durable and rugged than the Zimmer type litter.
5. The present standard litter is lighter in weight than the Zimmer type litter.⁶⁹

The Air Corps, however, stood firm in its demand and at length a compromise was reached. The Zimmer litter would not replace the Carlisle folding litter as a standard catalog item, but would be regarded merely as a supplemental litter to be procured only for the Air Corps.⁷⁰ In addition, the original purchase order for 75,000 folding litters was cut down to 25,000, the remainder to be standard straight pole litters.⁷¹

This, of course, was an anomalous situation. In many respects, the Air Corps had merely echoed objections which had been made fully three years before by procurement authorities within the Medical Department as well as by officials of the Planning and Training Division of The Surgeon General's Office.⁷² However, due to the opposition of the Equipment Laboratory, the slip joint, fixed stirrup type of

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litter remained the standard catalog item, while the litter which was actually being procured by the chief user of this item was accorded only "supplementary" status. This case affords one more illustration of the kind of predicament that could result from failure to make full use of the instrumentalities and procedures proscribed in AR 850-25.

The Medical Department Technical Committee, as described in this Army Regulation, had been designed to prevent just such difficulties. Differences of opinion between representatives of divisions and branches within the Medical Department could be aired in sub-committee meetings and, if still unresolved, could be referred to The Surgeon General for final decision. In meetings of the full committee, on which all interested arms and technical services were represented, difficulties at higher levels of authority could be discussed. In the event of continued nonconcurrence of a member, the question could then be referred to the Secretary of War.⁷³

Careful examination of Medical Department Technical Committee Minutes from 1941 through 1942 does not indicate that the changes in components of the folding aluminum litter were processed through that body. Neither was evidence found which would indicate that formal coordination of some other type was effected with the Air Corps when these changes were made. As a result, during the latter part of 1942, the Medical Department had two sets of specifications covering the folding litter. Furthermore, even as late as August, 1943, when the Zimmer type of folding litter had at last become the standard catalog item, the following communication from the Equipment Laboratory makes it clear that the initial controversy had not even yet been resolved.

Attention is again invited to the fact that this Laboratory has never approved the folding stirrup type of spreader bar as same is entirely inadequate and will not stand up under field conditions. It was accepted for use on the folding type litter, Item No. 99380, as the Air Corps desired this light folding litter and the litter as constructed would not fold unless the folding type stirrup was used. This was also accepted in spite of our report that this folding stirrup and spreader bar combination was not approved by this Laboratory. There can be expected considerable replacement of this item....⁷⁴

In conclusion, then, it may be said that neither of the two types of folding aluminum litters which were developed under Medical Department supervision between 1935 and 1941, was found to be completely satisfactory. The Carlisle model was not favored by the New York General Depot, the Planning and Training Division of The Surgeon General's

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Office, and the Air Corps. The Zimmer design, which was acceptable to all the critics of the slip joint litter, was vigorously and persistently opposed by the Equipment Laboratory. Fortunately, in the spring of 1943, a new folding wood litter was developed which met with the approval of all concerned. As we shall see, however, considerable experimentation over a rather broad field was necessary before the desired end result was achieved.

C. Gran Laboratories, Storm Lake, Iowa.

The Gran litter is reintroduced at this point in our chronological narrative because of certain new developments which were to cause considerable difficulty for research and development personnel. The factual background of this case may be summarized somewhat as follows. After demonstrations, in March, 1939, before officials of the Surgeon General's Office and members of The Medical Department Board, Dr. Gran shipped one of his v-shaped litters (see Fig. 12) to the Equipment Laboratory for a field test. On 24 July 1939, the Medical Department Board recommended, as a result of field test findings, that the litter be rejected.⁷⁵ This information was conveyed to the inventor of the litter, who also operated under the name "Gran Laboratories", on 31 July 1939 by The Surgeon General's Office.⁷⁶

On 7 July 1940, Dr. Gran appeared at The Surgeon General's Office and requested that the Army indorse his stretcher for civilian use. This request was refused.⁷⁷ Then on 5 May 1941, Dr. Gran again visited The Surgeon General's Office, seeking to have his litter reconsidered for use by the Army. At that time a new type of unit was contemplated for which, it was felt, the Gran stretcher might be of use as specialized equipment. The inventor was told that in the event such an organization were activated, his litter would be re-tested. However, the proposed unit was not formed, so no further action regarding the Gran litter was taken.⁷⁸ This would seem to have put an end to the matter, but such was not the case.

On 12 September 1941, a communication was received from the Honorable Clyde L. Herring, United States Senate, addressed to The Surgeon General's Office, and stating that Dr. Gran wished to demonstrate his stretcher to officials of the Defense Program. The Senator added that he would appreciate consideration of Gran's request together with any suggestions which might be made as to the practicability of the device.⁷⁹ The reply to the Senator, dated 15 September 1941, stated that any information which had been furnished The Surgeon General's Office by Dr. Gran and which he needed in demonstrating his litter before other agencies would be made available to him at his request. The letter then summarized briefly the information given in the above paragraph.⁸⁰

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On 15 September 1941, a letter from the Honorable Guy M. Gillette, addressed to Major General James C. Magee, The Surgeon General, was received. The concluding paragraph of this letter was as follows:

May I earnestly request that the most careful consideration be given to Dr. Gran's stretcher and that, if possible, arrangements be made for him to give a demonstration and present the matter to you or to those whom you may designate to represent you. I shall be very glad to receive any suggestions or to have an opportunity to discuss the matter with you or your representatives.⁸¹

In the absence of General Magee, the Acting Surgeon General replied, on 18 September 1941, by recounting in some detail the history of the Gran litter and the Medical Department's position. It was stated that, if certain proposed new units were activated at some future date, another test of the Gran litter would be conducted.⁸²

On 14 October 1941, Dr. Gran wrote The Surgeon General's Office and, citing Senator Herring's letter, requested permission to demonstrate his stretcher before the Civilian Defense Commission.⁸³ The Surgeon General's Office replied that the Commission was not under the jurisdiction of the War Department, and that, therefore, his letter was being forwarded to that agency.⁸⁴ On 22 November 1941, another communication was received from Dr. Gran requesting Surgeon General's Office approval of the Gran stretcher for those governmental agencies requiring such approval, or a statement of the reasons why such approval could not be given.⁸⁵ In reply, it was stated that the Gran litter had been reconsidered but that the disadvantages that were noted in the original test were still found to preclude adoption of the litter for military use. The 1939 test findings were then quoted in detail.⁸⁶

In a letter addressed to The Surgeon General, dated 11 December 1941, subject: "Removal of the Ban of the Surgeon General's Office against the demonstration of the Gran Portable Litter (Civilian Model)", the inventor stated that the litter referred to in the above letter was a military model, not the civilian model, and thus was resubmitting his request for The Surgeon General's endorsement.⁸⁷ After acknowledging receipt of this latest communication, The Surgeon General's Office replied:

It has never been the intention of the Medical Department to place a ban against use by civilian agencies upon any equipment submitted to this department.

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If civilian agencies require that equipment be approved by the Medical Department before they will accept it, that is a matter beyond our control.⁸⁸

The case, however, was not yet concluded. On 31 March 1942, The Surgeon General's Office forwarded on request certain portions of its files on the Gran litter to the Inspector General's Department.⁸⁹ Then, on 7 April 1942, The Surgeon General's Office sent to the Office of Civilian Defense a statement signed by an officer in the Surgery Division, to the effect that he felt the Gran litter could be profitably used in civilian defense. It was stated in the communication that the inclosed statement was simply a personal opinion.⁹⁰

No further developments appear to have taken place until 7 January 1944, when a communication was received in the Office of the Secretary of War from Senator Guy M. Gillette. The Senator referred to a letter recently received from Dr. Gran in which the latter stated that the War Department was planning to build box cars for the transportation of the sick and wounded, presumably because the regulation Army litter could not be used in Pullman cars.⁹¹ In reply, the Administrative Assistant to the Secretary of War stated that the report that the War Department was constructing box cars for the transportation of wounded soldiers was erroneous. In addition the Senator was informed of the two Medical Department rejections of the Gran litter.⁹²

On 29 June 1944, Senator Gillette enclosed another letter from Dr. Gran, dated 26 June 1944, and asked for comment from the Administrative Assistant to the Secretary of War. The first paragraph of Dr. Gran's letter was as follows:

I am resubmitting the litter to the War Department because the stretcher referred to was not the model referred to by the Medical Department Board in 1939. This stretcher would not go into a standard pullman car. The stretcher referred to in my letter was accepted by the Surgeon General in April, 1942. This stretcher has never previously to 1942 been submitted to the Surgeon General.⁹³

The letter drafted in reply to the above marks the concluding chapter in this voluminous correspondence. The War Department, after again tracing in detail the complete administrative history of the Gran litter, concluded its letter to Senator Gillette with this paragraph:

Reference is made to the statement that the stretcher referred to was accepted by The Surgeon General in April, 1942. The only record in the Office of The Surgeon General which indicates an approval is one made by the Surgery Division of that office on 6 April 1942, which is an opinion

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and states "that this stretcher can profitably be used in Civilian Defense". As previously stated this stretcher does not meet the requirements of the Medical Department Service of the Army as well as litters now standardized and in use today.⁹⁴

This somewhat detailed chronical of events relating to the Gran litter has been presented because it illustrates so forcibly what heavy inroads can be made against the time of Medical Department research and development personnel by a persistent individual who is not averse to seeking Congressional intervention to press his claims. The tangible gains achieved by Dr. Gran were, of course, negligible. Neither of the two Senators involved demanded anything more than reconsideration of the case, and The Surgeon General's Office stood firm in continuing to sustain the original findings of the Medical Department Board. However, the case lasted from March, 1939 through June, 1944, and the time and effort involved in handling this voluminous correspondence was a decided burden to Medical Department officials.

D. The Brumor Corporation, New York, N. Y.

On 19 May 1941, arrangements were made by The Surgeon General's Office to turn over to the Brumor Corporation of New York City, four standard aluminum pole litters to be used for experimental purposes in developing a new type of stirrup and spreader bar assembly.⁹⁵ Several months before, the company had discussed the possibility of producing a folding litter with plastic side poles and moulded plastic parts, but this idea had now been abandoned in favor of a steel pole litter with an extruded aluminum undercarriage.⁹⁶ On 20 May 1941, preliminary specifications covering the new Brumor stirrup and spreader bar assembly were presented to The Surgeon General's Office, and, a week later, the company was authorized to make up three experimental litters embodying this design to be field tested at Carlisle.⁹⁷

Upon receipt of the new litters, the Equipment Laboratory issued the standard test instructions to the 32nd Medical Battalion. The Brumor litter was to be tested in comparison with the regulation folding aluminum litter. Carries up to 1/2-mile were to be made, using a patient weighing 175 pounds or more. The litters were to be loaded from ambulance and cargo trucks, and the stirrup and spreader bar assemblies were to be tested thoroughly in mud and sand. In addition, certain specific questions were to be answered regarding the new model. During hand carry, was the whip of the poles excessive? Did whipping action of the poles cause the side hinges to open in such a way as to pinch the arm of the patient? Did the hinge fastening the spreader bar to the

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side pole catch the hands or fingers of the litter bearer when opening the litter? Did the overlapping portion of the wooden handle chip or break?⁹⁸

The Brumor folding litter weighed 20-1/4 pounds and was equipped with steel side poles, 1-3/4 inches outside diameter, 0.046-inch wall thickness, 77 inches long, and hinged at the center by means of a cast aluminum hinge somewhat similar to the Zimmer device. At the ends of the poles were wooden handles, 6-3/8 inches long tapering in size to 1-1/8 inches at their smallest section. The usual slip-on canvas cover was provided which had, however, six cut-outs; one at each hinge and one at each of the spreader bar attachments to the poles. The cover was held taut by tie strings at the four corners of the canvas which were fastened to the side poles.

The stirrup and spreader bar assembly was the most novel part of the new litter. The entire assembly was made of extruded aluminum straps, weighed 6.14 pounds per litter, and required 30 welds. The stirrups were welded to the spreader bars and were at right angles to the side poles when the litter was open. The spreader bars, which opened in the same direction, were attached to the side poles by 5/16-inch bolts which passed through the ends of semicircular shaped straps and through the poles. In closing and opening the litter, the semicircles left the inner side of the poles for about one inch and then snapped back on the poles. The usual hinge arrangement had been employed in the bar sections at the center.⁹⁹

After extensive field trials, the only component of the new litter which was favorably reported by the testing battalion was the steel tubing used for the side poles. These poles, it was found, developed no observable whipping action or bowing during casualty carries, and, except for the fact that they were heavier than the aluminum pole, were regarded as a satisfactory substitute. The aluminum hinge, however, was not considered rugged enough for field service. The sample litter broke at this point when a 175-pound patient was suddenly lifted. Also, the hinge was complicated in construction and, because of its milled parts, expensive. Finally, the litter handles were found to be uncomfortable. The bevel of these handles did not conform to the natural grip of litter bearers' hands, and thus threw the greatest strain on the thumbs and index fingers instead of the last three fingers.

As for the canvas cover, in addition to being expensive due to the six bound cut-outs, the tie strings failed to hold the canvas taut so that the cover tended to slip toward the center. This increasing sag ultimately left the patient resting directly on the ground. The stirrup and

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spreader bar assembly was found to be altogether unsatisfactory. Sudden stops and starts of the ambulance or truck caused the spreader bar to unlock and collapsed the litter. Similarly, striking the rear edge of the floor, the assembly collapsed. When kicked back into position the spreader bar frequently pinched the patient's arms and legs because of its snap hinge.¹

In conclusion, the 32nd Medical Battalion recommended rejection of the Brumer litter, and this recommendation was sustained by the Medical Department Equipment Laboratory in its final report of The Surgeon General's Office.² The steel side poles of the new litter were its only promising feature. If the Air Corps would allow the added weight, these poles could be used in place of aluminum, should a serious scarcity of that metal develop. In all other respects the Brumer litter's performance had been markedly inferior to that of the standard folding litter.

E. The United Metal Box Company, Brooklyn, New York.

In June, 1942, a modification of the slip joint type of connection for the folding litter was developed by the United Metal Box Company. The device consisted essentially of a shorter sleeve than was used in the standard litter, which was reinforced by a snap lock to keep the pole sections from pulling apart when the litter was open. A sample stretcher, incorporating this device, and equipped with steel side poles was demonstrated at the Equipment Laboratory on 5 June 1942.³ Regarded by Laboratory personnel as too weak for field use, the lock arrangement was redesigned by the manufacturer and, in the following month, resubmitted for examination and field test.⁴ Inasmuch as only one component of the new litter was under observation, the Equipment Laboratory departed from its usual procedure in issuing test instructions to the 32nd Medical Battalion.

Request that your organization have carried out such tests as you may deem necessary to determine the suitability of the lock of the all-steel collapsible pole litter, and that the findings and any recommendations you may wish to make be reported to this office informally.⁵

About the middle of July, 1942, tests were made with the litter loaded with a 180-pound patient, and with the litter empty. The stretcher was next folded and tested for handling under field conditions.⁶ In a report to the manufacturer, dated 28 July 1942, the Equipment Laboratory listed the field trial results as follows:

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Snap lock of one pole became depressed and joint lost rigidity. The sleeve end of the side pole section concerned became enlarged when the weight of the patient forced the joint below the horizontal, resulting in a more elliptical than round sleeve end, and lock was ineffective after this occurred.

Litter joints showed definite signs of damage when litter was dropped into soft shale fill from a height of three feet. Sleeve end of joint filled with mud and foreign material but without apparent effect on the serviceability of the locking device.⁷

On the basis of the above findings, the Laboratory stated that it was apparent that a longer and stronger sleeve, such as the one used on the standard slip joint folding litter, was necessary. In the event this change was made, however, the locking device would no longer be needed. There would be no problem in holding the pole sections together, so a lock would simply create an additional operation in getting the pole sections apart. The new device was, therefore, rejected. It could only be improved by duplicating the standard slip joint.⁸

F. Metallbau Koller, A. G., Basle, Switzerland.

On 5 November 1941, a packet of documents and photographs relating to two new types of folding litters was forwarded by the United States Military Attache at Bern, Switzerland to the Assistant Chief of Staff, G-2, Washington, D. C. According to the enclosed literature these litters, which had been developed by Metallbau Koller at Basle, Switzerland, had been adopted by the Swiss Army as peculiarly suitable to the evacuation of wounded over rugged, mountainous territory.⁹ Upon receipt of this descriptive material The Surgeon General's Office requested that efforts be made to obtain a full-sized model of each of the Koller designs for examinations and test. The Medical Department was especially interested in these Swiss litters as it was expected that mountain divisions would be activated at some time in the near future.¹⁰

Accordingly two pilot models were shipped to this country by the manufacturer, their transportation to the Equipment Laboratory was arranged through the Swiss Legation which agreed to pay the charges, and, on 2 June 1942, The Surgeon General's Office directed the Laboratory to subject the new litters as soon as received to thorough field tests and to render a formal report of findings.¹¹ Before the close of June, 1942, a two-man, collapsible litter and pack-carry litter had arrived at Carlisle. As usual, testing instructions

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were thereupon issued by the Laboratory to the 32nd Medical Battalion. In this instance, however, the instructions were highly general in nature.

It is requested that your organization carry out such tests as are deemed necessary to determine the strength, practicability, and usefulness of the subject litters.¹²

Both litters were basically similar in design. In certain respects they resembled the old Trench Litter in World War I.¹³ Their metal framework was oval in shape and consisted of two horseshoe-shaped sections whose open ends were hinged together. A rounded canvas cover was fastened to this continuous outer rail, which was constructed of steel tubing, by means of hooks placed along the ends and for a short distance down the sides of the metal rail. Four pieces of short tubing welded to the frame served as feet for the litter, and to these were attached four rods with downward curving handles. By means of a special cap and butterfly screw, these elongated handle bars would be turned horizontally or vertically, the size of the arc being controlled by a series of groove openings, or could be held rigidly in extended position.

These movable handle bars afforded a wide opportunity for converting the Koller litter to a variety of uses. By turning the handle bars vertically, the stretcher could be used as an emergency bandaging or field operating table, or to prevent the patient from becoming wet when the litter was put down in swampy country. By turning the handle bars upward and roofing with one tent cloth, protection was afforded against rain, wind, snow, and insects. By lowering one set of bars and keeping the other set fixed in the horizontal, the litter could be converted into a crude sledge for use in snow, on hills, or over sand. With additional equipment, such as wheels or skis, numerous other conversions were possible. For ordinary hand carry, however, the front handle bars were generally fixed, while the rear bars were adjusted to turn horizontally.

The collapsible litter was a one-piece assembly and weighed 22 pounds. It measured 24 by 73 inches when open and 24 by 38 inches when folded. This model folded in the middle. In contrast, the pack-carry litter could be separated into two parts, each of which weighed 14.5 pounds. These sections were identical so that the connection of any two of them would form a complete litter. Opened, the litter measured 24 by 73 inches—exactly the same as the first model. Folded into separate sections, each of which measured 24 by 39 inches, the dismantled litter could be readily carried as a marching pack. Aside from these one-piece and two-piece features, the two litters were virtually identical. Both were equipped with the movable handle bars, the oval shaped frame, and the hooked-on canvas.¹⁴

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The field test report of the 32nd Medical Battalion was completed on 7 July 1942, and forwarded to the Equipment Laboratory. The two litters, designated as the Koller Litter and the Koller Pack Litter, had been tested in comparison with the standard ash pole and aluminum pole litters, and also in comparison with manual saddleback carry. Test results were as follows: (1) Loaded with a 180-pound patient and hauled in an ambulance over a macadam road and then across open fields, the Koller Litter developed a whip of 3.5 inches, rendering it difficult for a patient to stay on the litter. The empty litter when folded could not be secured to the sides of the ambulance and so it interfered with movement within the ambulance, (2) Hand carried under simulated combat conditions, it was found that the empty litter was difficult to handle when the bearers deployed as it did not fold into a compact mass. Moreover, the time required to unfold or to assemble the litter for use was regarded as excessive.

The second type, the Koller Pack Litter, was loaded with a 153-pound patient and hand carried over a course 1.2 miles long. It was found that the framework cut and rubbed the bearer at contact points, was difficult to adjust for proper balance, and was extremely awkward to carry when empty. Bearers covered the course twice; once using the pack litter and once carrying the same patient by saddle back manual carry. All bearers expressed a preference for the latter type of carry. The only advantage found for this type of litter was in mountainous terrain or heavily wooded areas, where it permitted the bearer the use of his hands in climbing or descending steep grades and in going through dense forests.¹⁵

In its final report to The Surgeon General's Office, the Equipment Laboratory presented its conclusions as follows:

The disadvantages of the subject items found by the 32nd Medical Battalion during their test were in comparison to the standard field equipment under ordinary field conditions. It is believed that in such places as the standard litter could be used and the back carry would not be too long or over rough terrain, that the standard litter and the manual carry would make it unnecessary for special equipment. However, in such places as there may be scarcity of personnel, no reason for deployment, and terrain so rough that equipment must be carried on the back leaving free use of the hands, the Koller adjustable pole litter and the Koller back carry litter would prove valuable.¹⁶

Thus it was recommended that where special conditions warranted, the Swiss litters could be used to advantage.

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This was not, however, the end of the matter. On 8 June 1942, the agent in this country for Metallbau Koller informed The Surgeon General's Office that his principals in Basle had shipped a new and improved stretcher by air express on 21 May and that this model would also be available for test as soon as received. In a subsequent communication it was explained that the new design provided for complete swinging round of the handle bars and for a more satisfactory stretching of the canvas cover.¹⁷ However, due to a shortage of the light steel, the metal framework had been constructed from relatively heavy material which possessed a lower degree of elongation and tensile strength than the steel tubing used in the earlier models.¹⁸

On 15 August 1942, The Surgeon General's Office, having authorized the shipment of the new Koller litter to Carlisle, requested the Equipment Laboratory to submit a test report of findings as soon as possible.¹⁹ Only an "examination", and not a complete field test was requested, so the Laboratory apparently did not submit the new litter to the 32nd Medical Battalion for extensive testing. On 24 October 1942, a final report was rendered. It was reported that the improved Koller litter was essentially the same as the one previously tested by the Laboratory except for certain minor changes. The new method of attaching the carrying handles to the litter was regarded as an improvement as the points of stress were now reinforced at the points of application. An additional catch placed at the middle hinge was also considered superior to the earlier design.

It was found, however, that the new litter set up the same whipping motion when carrying a patient in a cross country ambulance, and it was felt that this would ultimately result in a permanent set in the metal framework. It was also noted that the spring catch of the handle connection was defective and would not only fail after prolonged use but would also eventually break the wire cable holding the canvas to the frame, against which it repeatedly struck. In summary the Laboratory acknowledged that certain features had been improved, but felt that its findings regarding the earlier models still applied; namely that the Koller litter was not a suitable substitute for any of the standard Medical Department litters but that it would be valuable for use under special conditions.²⁰

Since standardization of the Koller litter would have to await activation of mountain divisions or similar specialized units, no procurement action was initiated at this time.²¹ The further question may be raised, however, as to whether the Koller litter actually merited even the limited recommendation it had been given. A letter dated 12 March 1943, from the Director of the Medical Department Equipment Laboratory to the Commandant of the Medical Field Service School at Carlisle, suggests

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that the above recommendation may have been really intended as a polite form of rejection.

....we had this litter here in both the old and more recent models, and....we find that they will not serve to replace our standard litter and are, therefore, only a special piece of equipment of limited value and therefore not considered for adoption. Further, it is a complicated affair and we would expect many mechanical difficulties.²²

It will be remembered also that the litter had not been extensively tested in genuinely mountainous country. In Great Britain, however, such tests were conducted, and with the following results:

Exhaustive trials have been made with the Koller Stretcher over most difficult country. It is considered that this Stretcher, which is of a most ingenious design, is too complicated, too fragile, and definitely would not stand up to the stress and strain of mountain warfare.²³

Later, when a special development project was initiated by the Medical Department to produce a satisfactory mountain litter, it was significant that the Koller litter was not recommended for adoption.²⁴

G. Charles J. Williams, Saco, Maine.

In the preceding chapter it was pointed out how serious administrative difficulties were created by the extension of War Production Board activities into the minutia of Army litter research.²⁵ The Williams case, which is of little or no importance so far as development of the folding litter is concerned, is included here simply because it provides some of the earliest evidence of a gradual stiffening in attitude on the part of the Medical Department. The case also furnishes the first instance thus far encountered in which it was suggested by the Medical Department that a convenient solution of this problem of overlapping jurisdiction between it and the War Production Board would be to make use of the governmental agency which had been specifically established to perform just such coordination.

On 8 December 1942, the Technical Development Section of the War Production Board forwarded to The Surgeon General's Office a description and drawing of a combination stretcher and Army cot invented by Charles J. Williams of Saco, Maine. While it was not indicated whether or not the inventor had constructed a physical model as yet, the War Production Board appended this request:

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Will you please have your committee study this idea, and if found impractical or unsound then suggest some alternate or modification which will satisfactorily solve the problem.²⁶

Needless to say The Surgeon General's Office ignored the latter portion of this request. In reply it was stated that the Williams litter in no way conformed to standard sizes and specifications and consequently could not be interchanged with other litter equipment then in use, nor could it be adapted to the fittings in the various Medical Department vehicles in which it would presumably be used. It was recommended, therefore, that no further consideration be given the item of equipment in question. In concluding, The Surgeon General's Office made the following terse comment:

Equipment of this type has previously been sent to this office through the National Inventors' Council where it has undergone a sifting process and if it is not in line with our usual requirements, it is not given further consideration.²⁷

The reply was apparently effective. The records do not show that any further correspondence on this matter was received.

H. Zimmer Splint Company, New York, New York.

As we have seen in the previous chapter, the use of aluminum in the manufacture of Medical Department straight pole litters was discontinued shortly after the issuance of Conservation Directive No. 14 on 12 January 1942. Inasmuch as the folding pole litter was used principally in airplanes and tanks and was consequently procured in only relatively small quantity, the aluminum restriction was not immediately extended to this field.²⁸ The effects of the shortage, however, were nonetheless serious so far as this branch of litter research and development was concerned. The side poles of the new straight steel litter were smaller in outside diameter than those of the straight aluminum litter which was being temporarily replaced. If the customary interchangeability of parts was to be maintained, this meant that either a smaller dimension tubing would have to be used in the folding aluminum litter or, if this was incompatible with tensile strength requirements, a substitute material would have to be found.

Accordingly, on 21 February 1942, the Equipment Laboratory addressed an inquiry to the Aluminum Company of America to find out the possibility of constructing aluminum tubing with an outside diameter of 1-1/4 inches instead of the now standard 1-1/2 inches, which would still possess

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relatively the same rigidity characteristics of the old pole.²⁹ The same day the Laboratory wrote to the Zimmer Splint Company in New York City, requesting that a folding steel litter be constructed following the design of the aluminum pull-apart model.³⁰ The entire problem became considerably more crucial when, on 25 February 1942, the Aluminum Company of America replied that a reduction of 1/2-inch in outside diameter of the aluminum collapsible pole would necessitate a corresponding increase in wall thickness, thus materially increasing the weight per foot and rendering the pole much less satisfactory from an engineering standpoint. The company concluded by recommending that no reduction in outside diameter be made.³¹

As for the proposed folding steel litter, objections were immediately raised by the Zimmer organization regarding the slip joint specification suggested by the Laboratory. It was pointed out that the danger of corrosion made this device less desirable than certain other methods of connecting the pole sections. Unless protected in some manner, the sleeve of carbon steel would be likely to rust heavily. It was understood to be virtually impossible to lay down plating on the inside of the tube, and dipping in paint was not regarded as affording much hope of durability. The precision fit which was necessary with the slip joint type of construction was also cited as a disadvantage.³² In reply the Laboratory minimized the problems which had been raised.

I do believe, however, that the rusting of the sliding ends of our proposed steel folding litter has been greatly over emphasized. I cannot conceive how the ends could rust so badly (under the most adverse conditions) that the poles could not be slipped together. It is true that in time severe rusting would weaken the joint due to the wasting away of the metal but this would certainly be a matter of years of exposure under adverse conditions.³³

It was suggested, therefore, that construction of the new litter proceed along the lines originally prescribed with the single modification of cadmium plating the male section of the sliding sleeve. On 2 March 1942, the manufacturer replied that production had been started and that the new model would be available in the near future.³⁴ The records do not indicate the exact date on which the finished litter was received by the Laboratory, nor is there any evidence that this experimental model was formally field tested and reported upon to The Surgeon General's Office. In fact, the only other reference to this particular litter that was found is contained in the communication referred to much earlier in the chapter,³⁵ in which the Air Corps expressed its decided preference for a folding joint (hinged) type of folding litter

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instead of the slip joint variety. After stating this preference so far as the aluminum litter was concerned, the Air Corps then made the following comments regarding the steel litter:

The steel litter weighs about 8 pounds more than the aluminum litter. With aluminum litters, this means a saving of from 80 to 264 pounds, depending upon the type of airplane in which they are used. The bulk of the steel litter is greater than that of the aluminum folding litter due to the fact that the foot rests do not fold in. This will also make considerable difference in transporting litters in large number by air.³⁶

I. Zimmer-Thomson Corporation, Long Island City, New York.

After this final rejection by the Air Corps, nothing more was heard of the slip joint type of steel folding litter. Experimentation with steel tubing was not, however, immediately abandoned. The Zimmer-Thomson Corporation of Long Island City, New York, a manufacturing affiliate of the Zimmer Splint Company, continued the research work that had been initiated by the latter company and, before the close of 1942, had developed a wholly new type of folding litter which was demonstrated before officers of The Surgeon General's Office in the early part of 1943.³⁷

The new litter was double-folding, being constructed in three sections which were connected by means of folding hinges rather than slip joints. The standard steel undercarriage had been used but, in order to keep the assemblies from overlapping when the litter was folded, the two spreader bars had been staggered at different relative positions on the side rails. Thus, the distance between the feet or stirrups of the litter, which were attached to the spreader bars, was less than the amount required by Medical Department specifications.³⁸

This discrepancy was detected by The Surgeon General's Office when the new litter was first inspected and it was suggested that the difficulty might be overcome by having the spreader bars fold in opposite directions. This change was attempted by the company but there was still some overlapping of the assemblies when the litter was folded. It was then decided to employ one straight spreader bar and one curved bar, the patient to be placed on the canvas with his head toward the curved end. Using this method it was found that the litter could be folded compactly and also that the standard foot distance could be maintained.³⁹

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The modified design was completed before the end of February, 1943, and a pilot model submitted to the Equipment Laboratory at that time. It was pointed out by the manufacturer that the new litter could be collapsed and fitted into a carton or box, 7 inches square by 30 inches long. This was stated to be a 33-1/3 per cent reduction in the volume occupied by folding litters previously built by the company for the Medical Department. As previously mentioned, the new litter was equipped with folding hinges in place of the slip joints or earlier models. Inasmuch as the merits of these two types of joints had been the subject of considerable controversy in connection with the old folding aluminum litter, the opinion of this key manufacturer of Army litters may be of interest at this point.

A second feature of this litter is that the type of hinge which is employed does not depend on a close fit precision joint. Since stainless steel is too critical to be used for this purpose, it has been my personal feeling that all the folding litters which we have yet seen which utilized close fit sliding or pull-apart joints are very undesirable in that the plating or protective coating will wear off in very short time and consequently the parts will rust and render the litter useless. The hinge on the litter we plan to submit to you could endure considerable rusting without its operation being impaired.

As the poles of this new design litter are positively linked together we avoid the difficulty of handling which is encountered with the pull-apart type when it is taken apart, allowing the four poles to shift around more or less indiscriminately.⁴⁰

Two other factors were also alluded to by the manufacturer in submitting the new litter to the Laboratory for test. In the first place, the new model was a direct adaptation of the standard straight steel litter with the exception of one special spreader bar, and was consequently almost entirely interchangeable with the regulation item. The maintenance advantages of this feature were obvious. Secondly, the new litter was constructed of the same rail carbon steel tubing used in the production of the straight pole model. This material, which was a reclaimed steel, was stated to be not only tough and durable, but readily available in any quantity desired.⁴¹

On 5 March 1943, in company with seven other experimental litters of different types, the new Zimmer steel model was forwarded to the 32nd Medical Battalion for service test.

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In view of the subsequent decisiveness of this particular mass test, the instructions given by the Equipment Laboratory were surprisingly cursory. The earlier custom of sending detailed written instructions along with the request for a formal report of test findings was clearly not adhered to in this instance. The Laboratory merely stated:

It is requested that your organization have carried out such tests as you may deem necessary to compare and determine the suitability of the folding litters listed in Paragraph 2 below, and that the findings and any recommendations you may wish to make be reported to this office informally.⁴²

The reply from the 32nd Medical Battalion, made on 10 March 1943 upon completion of the field tests, was one of the least detailed reports yet received from that agency. It was stated that the following tests were conducted: (1) the litters were opened and closed; (2) a two-hundred pound patient was carried at quick time and at double time; (3) the litters were subjected to rough treatment; (4) the litters, while open, were twisted and forced as much as possible by two corpsmen; (5) attempts were made to open and close the litters after mud and snow had been applied to their joints; (6) the litters were used in all berths of the standard ambulance; (7) the litters were assembled by men in blind-fold.⁴³

The performance of each of the various litters under the tests enumerated above was not described. The balance of the report consisted simply of one-paragraph evaluations of the eight litters tested. Comment on the Zimmer-Thomson model, which was listed as second choice, was as follows:

This litter was equally well liked for its ease of opening and folding. However, it is heavier than the No. 8. The hinges are less rigid when the litter is open and here again the canvas is too loose allowing the patient to rest on the spreader bars. Otherwise this litter is well liked, very stable and withstands all types of treatment very well. It is thought that if some device could be arranged to stabilize the hinges when this litter is open it would be a great improvement.⁴⁴

The amount of formal interchange of information between the Equipment Laboratory and the 32nd Medical Battalion had been, as we have just seen, extremely scant. The effects of this deficiency in reporting were shortly to be seen at the next higher echelon of command. No separate report of test results regarding the new Zimmer litter appears to have been made in writing to The Surgeon General's Office.

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The only further mention of the litter that was found was the mere statement that it had been tested--included in a brief report, dated 16 March 1943, in which a double-folding laminated wood litter was recommended for adoption by the Medical Department.⁴⁵ While it is probable that impending new aluminum restrictions, which were soon to deny the use of this material even for folding litter construction, were the primary cause of this unusually hasty examination and report, the fact remains that little or no opportunity was given either The Surgeon General's Office, or for that matter the Equipment Laboratory, to make a careful and independent evaluation of the Zimmer litter on the basis of adequate and precise recorded data.

While the procedures by which rejection of the Zimmer litter had been accomplished would seem to be open to some question, no exception could be taken to the end results achieved by the Medical Department. The folding litter which was eventually selected by The Surgeon General's Office in preference to the steel and other models was soon to be regarded as the best folding litter ever developed for the United States Army. However, as we shall see in a moment, the Zimmer double-folding, hinged litter played an important part in this final development.

J. Carlisle Models I and II (Medical Department Equipment Laboratory).

While the Zimmer folding steel litter was considered too heavy for optimum field use, one feature of its design had from the first strongly impressed Equipment Laboratory officials: The novel idea of sectionalizing the side poles into three, instead of two, hinged sections, thereby producing a double-folding litter of unusual compactness, opened up possibilities which were immediately seized upon by the Laboratory. Early in 1943, research and development personnel at Carlisle Barracks set to work on the construction of a double-folding litter using laminated wood (as in the latest straight pole model) and using a hinge similar to the Zimmer type but designed to fit a square-shaped pole. A way was also devised to employ the standard undercarriage instead of the somewhat unorthodox running gear used in the Zimmer assembly.⁴⁶

Within several weeks two of these experimental wood litters had been constructed; Carlisle Model Number I (which had a square sleeve type joint) and Carlisle Model Number II (which had an insert type joint). In the view of the Director of the Equipment Laboratory both of these litters, which had been tested informally by the Laboratory, were equal to the Zimmer steel type in sturdiness, had the advantage of being lighter in weight, were not so apt to rust, and, by

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making use of laminated wood, eliminated the need for carbon steel poles which were then in danger of being declared as critical as aluminum. However, the hinges with which the litters had been equipped were admittedly weak. They had been constructed of scrap materials and it was no surprise to the Laboratory when subsequently this component was found defective by the 32nd Medical Battalion.⁴⁷

On 10 March 1943, the two Carlisle litters were transferred to the 32nd Medical Battalion and tested along with the Zimmer steel model and five other double-folding laminated wood models which had since been manufactured for the Laboratory by an outside manufacturer. As might have been expected, out of the eight litters tested, the Carlisle models were listed seventh and eighth, respectively. It will be noted, however, that weakness of the hinges was the principal defect cited. The testing agency's comment follows:

Carlisle Model No. I. This litter was found to be too unstable at the joint. It was likewise found to be too short and too hard to connect and disconnect with dirt and ice present.

Carlisle Model No. II. This litter was thought to be the poorest of the lot because of the weakness at the welded joint and because of the difficulty in keeping the joint in place once they were together.⁴⁸

As in the case of the Zimmer litter, no separate report on these two Carlisle Models was made to The Surgeon General's Office by the Equipment Laboratory. Simply a brief reference to the fact that they were tested was included in a subsequent communication, dated 16 March 1943.⁴⁹ The same comments as to the adequacy of these procedures as were given in the case of the Zimmer folding steel litter would seem to apply with equal force here.

K. Mikar Specialties Company, Baltimore, Maryland.

It will be recalled that the Mikar Specialties Company (division of National Store Fixture Company, Baltimore, Maryland) had, in December, 1942, successfully developed a laminated wood straight pole litter which was subsequently adopted as standard by the Medical Department. This company was now invited to assist in the production of a new folding wood litter. The nature and extent of its contribution to this latter undertaking, however, is still a matter of considerable controversy.

According to the Director of the Equipment Laboratory, Mikar Specialties Company did not make any important

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creative contribution to the development of the folding wood litter, but simply performed a largely routine manufacturing task. The unique double-folding arrangement (accomplished by a triple-sectionalizing of each side pole) was originated, it is stated by this officer, by the Zimmer-Thomson Corporation and was embodied in the double-folding steel litter which was submitted by that company early in 1943. As for the hinge design which was ultimately adopted by the Medical Department, this, it is contended, also originated with the Zimmer-Thomson Corporation, but was later modified by the Equipment Laboratory to fit the laminated wood pole. All that Mikar Specialties Company had done, therefore, apart from simple fabrication, had been to "remedy a few defects chiefly in hinge materials used" in the original Carlisle Models.⁵⁰

An opposing viewpoint on this question was held by Mikar Specialties Company, and its position was sustained to a considerable extent by the Chief of the Field Equipment Branch of the Plans Division, Office of The Surgeon General, who had also been active in this phase of the development work. According to this version the contribution of Mikar Specialties Company had been considerable. The problem of developing a folding type litter with satisfactory hinges had by no means been solved by the time Mikar Specialties Company entered the picture. In the words of the Chief of the Field Equipment Branch:

. . . This had been attempted by a number of organizations for about 4 or 5 months prior to this request with unsatisfactory results. The Mikar Specialties Company was successful in developing litters of this type which passed the test of our Laboratory at Carlisle Barracks and the Laboratory of the Air Corps at Wright Field.⁵¹

Whatever the proper apportionment of credit may have been in this case, in the early part of March, 1943, a double-folding laminated wood litter (which was subsequently to meet with the approval of all Medical Department officers concerned) was shipped by Mikar Specialties Company to the Equipment Laboratory for final field test.⁵²

The new litter (See Fig. 13) was 90 inches in over-all length, was 22 inches wide, and weighed 20 pounds. Slip-on canvas, 72 by 22-7/8 inches, served as the cover or bed of the litter, and was designed with two semi-circular cut-outs on each side where the pole hinges were located. The material from which the side poles had been constructed was identical with that which had been used in the case of the new straight wood litter; laminated wood, 6-ply, 1-1/2

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by 1-1/2 inches, with corners rounded. Each pole, however, was divided into three sections so that the litter could be double-folded on its longitudinal axis. Like the straight pole litter, handles had been formed merely by tapering the poles for 6 inches at the ends.

The stirrups of the new litter were of steel construction and were 3-1/8 inches wide and 4 inches high with braces. They were bolted to the poles 22 inches from the pole ends. As in the case of the straight wood litter, the spreader bars extended crosswise at the stirrups. The hinge with which the new litter had been equipped consisted of a steel channel to which the ends of adjoining pole sections were attached. In opening the litter these pole sections swung in toward one another until the ends formed a snug fit. The bottom of the metal channel supported and held the sections in position during casualty carry. Finally, the litter was equipped with two web straps, attached to the poles at the stirrup bolts, which could be used in strapping the collapsed litter for easier handling and storage.⁵³

In addition to the above model, four more litters, incorporating minor variations in design, were also shipped to the Equipment Laboratory for test.⁵⁴ Inasmuch as the testing instructions issued by the Laboratory as well as the description of the tests conducted by the 32nd Medical Battalion have already been quoted in connection with the Zimmer folding steel litter, they will be not repeated here. Out of the 8 litters tested, the model described in the above paragraph was rated as first choice, while the miscellaneous designs were all rated as inferior to the Zimmer steel litter, though superior to the two models constructed by the Laboratory itself.⁵⁵ The comment on the preferred "Mikar" litter was as follows:

Litter No. 8 is very stable, easily opened and closed. It was chosen over the Zimmer-Thomson because of its lightness and the fact that it remained more rigid at the hinges. However, this litter withstood all tests very well, but the canvas was too loose allowing the patient to sag and rest on the spreader bars while traversing rough terrain. Men handling this litter liked it very much.⁵⁶

In a final report to The Surgeon General's Office, the Equipment Laboratory gave its recommendation, on the basis of the mass field trials that had been conducted.

Accelerated service tests and Laboratory tests performed in this Laboratory and by the 32nd Medical Battalion, Carlisle Barracks, Pa.,

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revealed that the litter in question was undoubtedly superior in all respects to any of the others tested. It is easy to handle when either open or closed. It is compact, sturdy, and comfortable. The litter when closed is 31 inches long, 8 inches wide, and 7 inches high. Its weight is 20-1/2 pounds. In all respects it compares favorably with the standard aluminum folding litter.⁵⁷

It was then recommended by the Laboratory that the new double-folding laminated wood litter be considered a suitable folding litter for use by the Medical Department.⁵⁸

On 2 April 1943 a series of static loading tests were performed on the new folding wood litter by the Aero Medical Research Laboratory.⁵⁹ The results were satisfactory. The detailed report, which was forwarded to The Surgeon General's Office on 22 April 1943, showed that center section deflection had ranged from 1 inch, under a weight load of 200 pounds, to 7-1/8 inches under a load of 1200 pounds. Only when the litter was being made free with 1300 pounds did one of the poles break at the sleeve.⁶⁰

With the results of all tests now in, there was no longer any doubt that the Medical Department would approve of the new double-folding wood litter as a standard equipment item. A controversy now arose between the Medical Department and Mikar Specialties Company regarding development costs. As the general aspects of this particular issue were discussed at some length in the preceding chapter,⁶¹ only a few additional comments will be made here. As for the specific estimate of costs presented by the manufacturer for this second development period (the first period covered development of the straight wood litter), the bill was not a small one. Mikar Specialties Company listed as the cost of its research and manufacturing efforts from 2 January 1943 to 1 April 1943 the sum of \$25,108.58. This amount included a direct labor charge of \$3,550.20, factory overhead \$4,615.26, general and administrative overhead \$2,130.12, materials \$313.00, executive salaries \$6,500.00, and finally \$8,000.00 for "Development Fee for Period".⁶²

The inflation of this company's bid for the initial production of the new laminated wood folding litter by the inclusion of its development costs was instrumental in its failure to receive this opening contract. Unlike the case of the straight wood litter, however, this temporary elimination of the key manufacturer did not produce serious production difficulties. Since the laminations for the folding pole could be produced in relatively small sections, the large presses needed for the manufacture of the straight pole were not necessary. Consequently, as we shall see, the Medical Department experienced no difficulty in finding adequate out-

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side sources of supply. The failure of Mikar Specialties Company to obtain a substantial portion of the initial production did, however, lead to prolonged negotiations with the Medical Department over the question of development costs. As was mentioned in the preceding chapter, it is hoped that such difficulties may be eliminated in the future by the new system of advance development contracts.

L. The Aluminum Shortage.

In looking back over this second phase of Development Project, F-7, one aspect stands out with particular sharpness: the haste, leading at times to an extremely cursory handling of formal procedures, with which experimental work was carried out. The need for haste was by no means illusory. Since the beginning of the project there had been a constant tightening of aluminum restrictions. In March, 1942, the use of aluminum for the production of straight pole litters had been denied, and early in February, 1943, The Surgeon General's Office was called upon to justify even the relatively small amount of aluminum which was still being allocated for the manufacture of folding pole litters. In a memorandum to the Under-Secretary of War, dated 4 February 1943, The Surgeon General's Office stated that while the production of folding aluminum poles would have to continue through February and March, progress was being made in the development of a bonded wood folding litter and it was hoped that within the next sixty days the remaining structural problems affecting that litter would be solved.⁶³

There was, therefore, the greatest pressure on the Medical Department to produce a substitute folding litter in the shortest possible time. To a considerable extent, no doubt, many of the procedural lapses which have been noted in the preceding section could be attributed to this unremitting outside pressure. It is noteworthy that, despite this haste and the administrative short-cuts it necessitated, a satisfactory litter was developed and placed under procurement by the Medical Department in time to meet the anticipated deadline.

IV. Standardization and Procurement Phases.

A. Standardization Phase.

The double-folding, laminated wood litter was apparently never formally processed for standardization through the Medical Department Technical Committee. A careful examination of the minutes of all meetings of this committee from 1 January 1943 until formal suspension of Development Project,

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F-7 on 24 July 1943 disclosed no reference to this equipment item. The new litter did have, of course, the recommendation of the Equipment Laboratory. Moreover, in a letter dated 16 March 1943, Army Air Forces had informed The Surgeon General's Office that if a satisfactory folding wood litter could be developed it would be preferable to the new straight wood litter as a substitute for the standard aluminum model.⁶⁴ While These actions were in no sense equivalent to formal compliance with the provisions of AR 850-25, they at least furnished some basis for the step which was next taken. On 15 May 1943, by Surgeon General's Office Circular Letter, the double folding laminated wood litter was added to the Medical Supply Catalog as a standard item.⁶⁵

B. Procurement Phase.

At first glance it would seem that research and development personnel had, in their search for a substitute for the folding aluminum litter, a much more leisurely deadline to meet than had been the case of the straight litter project. In terms of the time factor alone, that was true. Both development projects had been initiated at about the same time, yet the aluminum restriction was applied to straight pole litter production on 3 March 1942, whereas the manufacture of folding aluminum litters was allowed to continue through the spring of 1943.⁶⁶ The time gain in the latter instance, however, was largely illusory. Since the straight pole litter project carried an "A" priority, the attention of the Equipment Laboratory was centered on this field of activity, and in numerous instances experimentation with a new construction material was not even begun with respect to the folding pole litter until the substance had been found acceptable for use with the straight litter.

As we have seen, modest allocations of aluminum were obtained for the months of February and March of 1943. Furthermore, it is evident that deliveries on uncompleted contracts for folding aluminum litter production were permitted after March, 1943.⁶⁷ The critical shortage, therefore, was not to become fully operative in this field until the summer of that year. Against this background of developments it can be readily seen that the race against time had again been won by the Medical Department. Approved by the Equipment Laboratory on 16 March 1943, the new laminated wood folding litter was placed under procurement the following month. On 10 April 1943, an order was placed by the Medical Department for the manufacture of 38,554 of the new litters at a unit cost of \$8.65. The first delivery under the contract was made on 21 May 1943, when 1,100 folding wood litters were received by Medical Supply Depots. By the end of June, 1943, 11,000 of the new models had been delivered and, by the 4th of December, 1943 the entire

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38,554 litters had been received.⁶⁸

An understanding of the procurement picture as it existed during this period can be obtained from an inspection of the following table.⁶⁹

	<u>Litter, Folding, Aluminum</u>	<u>Litter, Folding, Wood</u>
Net Stock		
(1 Jan. 1943)	10,948	0
Issues		
(1 Jan. 1943 to 30 Sep. 1943)	4,078	4,199
Deliveries		
(1 Jan. 1943 to 30 Sep. 1943)	12,604	25,485
Net Stock		
(30 Sep. 1943)	2,696	13,741
Contracts		
(30 Sep. 1943)	484	47,773

The procurement history of the folding wood litter, in view of the relatively limited uses for which the item had been designed, is impressive. After the initial production order of 10 April 1943 had been fulfilled, a second contract was awarded for the manufacture of 30,666 additional folding wood litters, unit cost being reduced to \$8.55. As of 25 January 1945, all of these new litters had been delivered, making a total of 69,220 folding wood litters available for combat service.⁷⁰ Comparing this procurement record with that of the straight wood litter, where total production was only 5,363, it will be seen that the folding litter was the item in which laminated wood performed its greatest service for the Medical Department.

V. Evaluation of the Folding Wood Litter.

A. The Folding Wood Litter versus the Folding Aluminum Litter.

The fact that the side poles of the folding wood litter were constructed of triple-ply laminated wood instead of duraluminum, that the poles were square with rounded corners instead of tubular, and that the handles were of the integral rather than the insert type, were not among the reasons generally advanced in asserting the superiority of the folding wood litter over the aluminum model. The straight wood litter had possessed all of these distinguishing characteristics and yet as soon as aluminum was again available the laminated wood item had been immediately superseded.

The superiority of the folding wood litter lay rather in certain other unique structural features. One of these was the special channel hinge of the laminated wood design which had been readily accepted by all interested agencies. Such acceptance was in marked contrast to the almost bitter controversies which took place, first when the slip joint was initially presented for standardization, and later when the question arose as to whether the slip joint or the newly developed link hinge was to be adopted as a standard component for the folding aluminum litter. Even today, it may be observed parenthetically, this latter disagreement does not appear to have been successfully resolved.

Secondly, the double-folding feature of the new wood litter offered decided advantages over the single fold of the aluminum design. Because of the sharp decrease in the length dimension, the new litter could be collapsed into a smaller cubic space, thereby simplifying greatly problems of both storage and handling. Where storage quarters were cramped as in the case of tanks, or where loading and unloading of empty litter had to be performed through small door openings as in the case of many of the early ambulance and cargo planes, the advantages of the double-folding model were self-evident. Furthermore, since the wood side poles were divided into three sections instead of two, it was no longer difficult to find a sufficient number of manufacturers who were equipped with presses large enough to turn out the specified laminations.

Finally, from the standpoint of durability and serviceability in the field, the Medical Department was outspoken in its preference for the folding wood litter. On 20 October 1943, Colonel Paul I. Robinson, Director of the Procurement Division of The Surgeon General's Office, summed up this matter as follows:

The double-folding laminated wood litter is considered the most satisfactory by the Plans Division of all the folding litters. The folding steel and aluminum litters . . . have not stood up as well under field conditions as the wooden litter.⁷¹

As conclusive evidence of Medical Department preference, on 5 April 1944, The Surgeon General's Office submitted the proposal that the folding wood litter be adopted as the only standard Medical Department folding litter. The folding aluminum litter was to be reduced as soon as practicable to the classification of limited standard, issued models to be repaired simply by cannibalization after stocks of repair parts had been exhausted.⁷² Although more than a year's delay was encountered, this proposal received Army Service Forces

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sanction in July, 1945.⁷³

B. The Folding Wood Litter versus the Straight Wood Litter.

In terms of actual usefulness to the Medical Department, the folding wood litter was a decidedly more profitable development than the straight wood litter. Procurement data indicates this fact clearly. As of 25 January 1945, more than 69,000 of the folding type wood litters had been procured as against 5,363 for the straight wood pole models.⁷⁴ Furthermore, from the standpoint of ease of manufacture, the folding wood litter was superior to its straight pole counterpart. No unusual problems were encountered in the manufacture of the former whereas, as was pointed out at some length in the preceding chapter, because of the large presses needed to produce laminations of the length specified for the latter model there was a question at the start as to whether this litter could have been produced in quantity had the occasion demanded.⁷⁵

Again, perhaps the most convincing evidence was the action taken by the Medical Department itself. On 4 April 1944, The Surgeon General's Office recommended that the folding wood litter be continued as a standard catalog item, but that the straight wood litter be replaced by the straight aluminum model and reclassified to limited standard.⁷⁶ While this proposal was subsequently tabled, in July, 1945, the straight wood litter was reduced, with Army Service Forces approval, to the status of substitute standard.⁷⁷

C. The Folding Wood Litter versus the Straight Aluminum Litter.

Apparently the only operational complaint registered against the folding wood litter was concerned with its use with the collapsible field carrier. It was found during amphibious training that when the occupied litter was placed on the field carrier the center section of the litter would not remain rigid but tilted upward, thus tending to make the feet and head of the patient hang down.⁷⁸ A thorough study of this defect was made by the Equipment Laboratory during the early part of 1944, and a large number of hinge locks designed to remedy the difficulty were tested. It was concluded, however, that this undesirable collapsing of the ends of the litter under the conditions noted could not be corrected unless major changes in design were accomplished.⁷⁹ Accordingly, The Surgeon General's Office, on 25 April 1944, recommended that units issued the collapsible field carrier for use in medical evacuation of personnel in amphibious operations would henceforth receive the straight

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aluminum litter instead of the folding wood litter.⁸⁰

The role of the folding wood litter in the evacuation process was, of course, not greatly diminished by the above decision. Much more serious, however, was a policy change that had occurred several months earlier with respect to the equipment to be used in aerial evacuation. On 4 February 1944, the Air Corps submitted the following recommendation to The Surgeon General's Office:

This Headquarters has been informed by the Conservation Section of the War Production Board that aluminum is available for litter poles.

It is recommended that straight aluminum pole litters be secured for the Army Air Forces, for the remainder of 1944 and 1945.⁸¹

This decision, which was subsequently approved and forwarded through procurement channels, was of far-reaching importance so far as the folding litter was concerned. It signified that the litter which had been originally designed almost exclusively for airplane use had now been supplanted, in Air Corps procurement, by the standard ground force litter. There is no documentary indication, however, that this unusual turn of events was the result of inferior performance of the folding wood litter in air evacuation. The data at hand disclose no criticisms of this sort by the Air Corps. It appears instead that this late shift in preference came as a result of certain basic changes in aircraft design which rendered unnecessary the further exclusive use of special folding litters.

By the early part of 1944, airplane doors had been greatly enlarged so that, in the loading and unloading of empty litters, cubic size of the collapsed litter was no longer a crucial factor.⁸² Furthermore, the interior of cargo and transport planes had been so greatly enlarged that some were now capable of accommodating as many as 36 patients at a time.⁸³ These changes virtually eliminated the unique storage problems that had previously existed. The net result of these and other developments was that the folding litter, as such, was no longer an indispensable item in aerial evacuation.

VI. Project Termination.

The suspension of Development Project, F-7, Litter, Folding was carried out in complete accordance with the requirements of AR 850-25. Noting that no progress had been reported on the above project, The Surgeon General's Office, in the early part of July, 1943 formally requested advice from the Equipment Laboratory as to whether it should be dropped

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or suspended.⁸⁴ On 8 July 1943, the Laboratory replied with the recommendation that the project be suspended as a reopening would be warranted as soon as the material situation improved.⁸⁵

At its meeting 19 July 1943, the Medical Department Technical Committee approved the above recommendation and, three days later, this decision was submitted by The Surgeon General's Office to the Commanding General, Army Service Forces for final approval.⁸⁶ This request was granted and, before the close of the month, the Equipment Laboratory was officially notified to suspend work on the subject project.⁸⁷ It will be noted that conformance with the provisions of AR 850-25 regarding research and development activities dates roughly from this period in 1943.

VII. Conclusion.

A. Testing and Reporting Procedures.

Considering first the conduct and reporting of engineering tests, much the same comments can be made with regard to Development Project, T-7 as were made in the preceding chapter relative to straight pole litter development. From a study of the available documents it would appear that with one exception the engineering tests to which the various experimental folding litters were subjected were extremely rudimentary in nature. Official reports include no mention of the use by the Equipment Laboratory of mechanical testing devices, and analytical data regarding structural features of the litter were rarely expressed in quantitative terms. Typically such information took the form of deductive reasoning, based largely on visual observation and past experience. In one instance only, standard static load tests were performed and statistically reported by the Aero Medical Research Laboratory at Wright Field.⁸⁸

The trend in field tests and field test reporting likewise follows much the same pattern that was noted in the preceding chapter. Throughout 1941, and during the early part of 1942, detailed testing instructions were issued by the Equipment Laboratory for the guidance of the 32nd Medical Battalion; carefully prepared, itemized test reports were forwarded in turn by the testing agency; the final reports and recommendations which were sent to The Surgeon General's Office were sufficiently detailed and comprehensive to afford full opportunity for an independent review of the performance record of the item in question. This policy of extensive field testing and careful reporting was, however,

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reversed during the later half of 1942 and, by the close of the first quarter of 1943, the above procedures had, in substance, been largely abandoned.

The case of the laminated wood folding litter, which was to be tested comparatively with seven other experimental litters, furnishes a vivid illustration of the changes in practice that had occurred during this latter period. Instructions to the 32nd Medical Battalion merely stated that whatever tests that were deemed necessary should be conducted. The formal test report subsequently submitted to the Equipment Laboratory, covering the performance of the eight litters in question, was slightly over one page in length. No account of individual test results was given. The litters were listed in order of preference, and in each instance a brief statement of the reasons for the rating was appended. The final report to The Surgeon General's Office contained nothing in the way of test data. Aside from certain general remarks about the new litter, the report simply stated that the litter had been tested in comparison with seven other models, had demonstrated its superiority, and was therefore recommended for adoption by the Medical Department.

From the above description it can be seen that independent and thoroughgoing review of action taken by lower echelons of command and based on written records, was no longer possible. What had been retained were simply the outward forms of compliance with this procedure.

B. Development Cost Policy.

The adoption of the folding wood litter led to a controversy between the Mikar Specialties Company and the Medical Department over the question of development costs which soon became part of a larger controversy involving both the straight and folding laminated wood litters. Inasmuch as this subject was dealt with at considerable length in the preceding chapter, no effort will be made here to elaborate on that analysis. It should be repeated, however, that the policy of waiting until development work had been completed before attempting to reach an understanding regarding the costs involved, was soon to be superseded. In February, 1944, a system of pre-negotiated Development Contracts was instituted which, from all present indications, should effectively solve such problems in the future.

C. Problems of Administrative Coordination.

Except for the procedures followed in formally suspending Development Project, F-7, the provisions of

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AR 850-25 do not appear to have been more closely followed than in the case of the straight pole litter project. There seem to be no written indications that the various important modifications which were made in the folding aluminum litter were ever officially cleared with all interested arms and services as required by regulations, or that the folding wood litter was ever formally processed for standardization through the Medical Department Technical Committee. While, generally speaking, this lack of conformance with Army Regulations does not appear to have led to serious difficulties, in one instance it did produce an extremely anomalous situation.

In the latter part of 1941, existing specifications for the folding aluminum litter were amended to provide for the adoption of the new pressed steel stirrup and spreader bar assembly in place of the old extruded aluminum undercarriage. In the new specifications, however, not only was this change made but, in addition, the Zimmer link hinge was replaced by an earlier slip joint design. While both of these modifications in components could have been easily processed through the Medical Department Technical Committee, thereby achieving complete and immediate coordination with all interested agencies, the records show that this was not done. Instead, it was not until May, 1942, when the differences between the old and new litter designs were brought to the attention of Air Corps authorities by the Zimmer Manufacturing Company, that Air Corps opposition to the slip joint substitution was conveyed to the Medical Department.

As a result, although the new specifications were temporarily continued in force, the Medical Department agreed to purchase as a supplementary litter the link hinge model desired by the Air Corps. In short, months after specifications had been drawn up and approved, it was forcibly called to the attention of the Medical Department that they were not acceptable to the one agency which was at that time the principal user of the item in question. That such awkward situations could have been prevented by a closer adherence to the administrative principles laid down in AR 850-25 was a thesis that a number of Medical Department officers were to support in the months that followed. The need for closer coordination of research and development activities, especially with respect to final adoption or modification of Medical Department items, was increasingly recognized during the latter part of 1943, and certain reforms were instituted. By February, 1944, as a culmination of several reorganizations within The Surgeon General's Office and a gradual standardization of administrative procedures, the desired degree of conformance with the provisions of AR 850-25 was finally achieved.⁸⁹ As we shall see, these new policies have continued in operation up to the present date.

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In addition to the above, several minor problems of administrative coordination were presented in this chapter. In case of the Gran Laboratories of Storm Lake, Iowa, the inherent responsibilities of the Medical Department to Congress were highlighted for the first time. In this connection it was shown how, in the absence of special personnel to handle Congressional inquiries, a heavy additional work load was placed on the shoulders of research and development officials charged with the preparation of replies to these inquiries. In view of the fact that correspondence between the Medical Department and various United States Senators on the subject of the Gran litter extended from 1941 through 1944, it can be seen that the time and effort expended by these key research officials was considerable.

The problem of overlapping jurisdiction between the War Production Board and the Medical Department on questions of research and development was discussed at some length in connection with the development of the straight pole litter. Reference to the Williams litter was included in the present chapter because the policies followed by the Medical Department in that case pointed the way toward a solution of the problem. In place of direct communication with the Medical Department, it was suggested that the War Production Board should forward all research ideas and suggestions received by it to the National Inventors' Council, an agency which had been specifically established to serve as a clearing house for such information. In the instance in question, this method of approach successfully closed the case.

The relationship between The Surgeon General's Office and the Medical Department Equipment Laboratory during the development of the folding pole litter had both its harmonious and discordant aspects. In the latter category was the prolonged controversy which ensued over the question of whether the slip joint or the link hinge was to be preferred for use with the folding aluminum litter. Although, from an organizational standpoint, the Equipment Laboratory was a subordinate instrumentality of The Surgeon General's Office, the former agency held out to the very end in opposing adoption of the folding hinge. Even though the New York General Depot, the Air Corps, and the manufacturer who had produced both types of litter were allied with the Planning and Training Division of The Surgeon General's Office in favoring acceptance of the link hinge, this issue was apparently never completely resolved.

In all other respects, however, unusually close coordination was maintained between The Surgeon General's Office and the Equipment Laboratory during this period. This policy of joint action was particularly noticeable in the handling of manufacturing relationships. It is, of course,

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true that fewer manufacturers were engaged in the development of the folding pole litter than with the straight pole litter, and that the problem of over-all coordination was thus somewhat simplified. Nevertheless, in every important instance during the course of Development Project, F-7, manufacturers had the benefit of consistent and informed guidance from both of these Medical Department agencies.⁹⁰ As a result, and in conspicuous contrast to the quality of industrial supervision described in the preceding chapter, folding pole litter research was carried on at a near maximum of managerial unity, and hence with a minimum of unnecessary expense and delay for the manufacturers themselves.

D. Contributions of Development Project, F-7.

The amazingly rapid emergence of the airplane and the tank as key weapons of modern warfare necessitated almost revolutionary changes in the procedures of medical evacuation. That these changes would, in turn, create corresponding demands in the field of litter research and development was, of course, inevitable. The increasing use of cargo, transport, and hospital planes, for example, created an urgent need for the development of a special airplane litter. Secondly, the growth of air power led to the activation of parachute troop and airborne infantry units. A litter was therefore needed which not only could be transported in considerable quantity by plane but which, if possible, could be carried pack-fashion on the back of the individual soldier. Finally, with the large-scale organization of armored divisions, it was necessary for the Medical Department to produce a litter which could be collapsed into a package small enough to be conveniently stored in the cramped quarters of tanks and other mechanized vehicles.

None of the Medical Department litters developed prior to 1932 was capable of fulfilling these manifold requirements. It was evident that the Regulation Canvas litter, with its rigid side poles, was in no way adaptable. The Metal litter, which had been developed in 1922 as a modification of an earlier Stokes Navy design had, it is true, served satisfactorily for a time as an airplane as well as naval litter. However, as the riding quality of airplanes was improved and as airport facilities for the horizontal loading and unloading of casualties were expanded, the advantages of this heavy, basket-type of litter were soon outweighed by disadvantages. This, then, was the situation in 1932, when Development Project, F-7 was initiated. What was urgently needed was a wholly new type of litter which would successfully meet not merely one but all of the specialized demands that had been so recently created.

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The first phase of the new project, extending roughly from 1932 to 1940, resulted in the development of a folding aluminum litter which did, by and large, fulfill all requirements. Except for three unique features, the new litter was virtually a duplicate of the straight pole aluminum litter, the development of which had been practically completed by 1932. As in the straight pole model, the side poles were of duraluminum tubing with insert handles, the undercarriage was constructed of cast aluminum, and the litter cover was of the slip-on canvas type. However, unlike the standard model, the new design called for sectionalized side poles, a slip-joint connection, and staggered undercarriage assemblies. The result was a single-folding, pull-apart litter which possessed the two prime requisites of lightness and compactness. While the material used in the construction of the undercarriage went through a cycle of changes from cast aluminum to extruded aluminum to pressed steel, these improvements were the by-products of straight pole rather than folding pole litter research. The only other unique contribution of Development Project, F-7, during the first phase, was the development of a link hinge which made possible the folding of the pole sections, in place of the previous and more rudimentary pull-apart arrangement.

The second phase of this project extended from 1940 to 1943, and has been the one with which this study has been chiefly concerned. In this instance, the new straight pole laminated wood litter served as the governing research model. Like its straight pole counterpart the new folding pole litter, as ultimately perfected, was equipped with laminated wood side poles, integral pole handles, and standard slip-on canvas. Unique in the new design was a triple-sectionalizing of the side poles to produce a double instead of a single fold. Because of these double-folding poles which were channel-hinged, the new litter soon came to be universally regarded as the best of the Medical Department folding litters. Collapsible into a much smaller cubic space than its predecessor, the new folding wood model was regarded as ideal, not only for Air Corps needs but even more particularly for use in tanks and for pack carry.

In summary, despite administrative difficulties and a certain amount of misdirection, the achievements of the Medical Department through Development Project, F-7, were considerable. The folding aluminum litter not only filled the need for a suitable airplane litter at a time when existing models had become seriously outmoded, but it also first introduced the folding principle into litter construction. The folding wood litter was likewise a development of the first importance. Not only was it produced in time to be of service during the aluminum shortage, but, even with the reappearance of aluminum, continued to be issued in prefer-

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once to its predecessor. The double-folding feature of this new litter, moreover, appears to have been a contribution of fundamental significance. It continues to serve today as a model for the latest Medical Department research efforts in this field.⁹¹

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FOOTNOTES TO CHAPTER III.

- ¹Grant, David, N. W., Maj. Gen., U.S.A., Air Surgeon, A.A.F., "Air Evacuation," The Military Surgeon, Feb., 1944, Vol. 94, No. 2, pp. 80-82. The factual material in this introductory section has been drawn largely from General Grant's article.
- ²Ibid., p. 80.
- ³"Patients Evacuated by Aircraft," The Bulletin of the U. S. Medical Department, No. 77, Jun., 1944, p. 9.
- ⁴Ibid., p. 9.
- ⁵Heflebower, op. cit., pp. 1-10. The litter descriptions and other historical data contained in this section are based on Gen. Heflebower's 1928 monograph.
- ⁶Ibid., p. 9.
- ⁷Monthly Progress Report, M.D.E.L., Oct., 1941, pp. 5, 9 (M.D.E.L.).
- ⁸G.L. McKinney, Col., M.C., U.S.A., Dir., Equipment Laboratory, "Some Recent Activities and Developments at the Medical Department Equipment Laboratory, Carlisle Barracks, Pa.," The Army Medical Bulletin, No. 37, Oct., 1936, pp. 45, 50-51.
- ⁹Supra., p. 40.
- ¹⁰Supra., p. 61.
- ¹¹Ltr. to S.G.O., fr. M.D.E.L., 16 Mar. 1943; subject: "Litter, Double-Fold, Laminated, Wooden Pole" (M.D.E.L.).
- ¹²Robinson, op. cit., p. 6. Also see Min. of M.D.T.C., 25 Jun. 1945 (Hist. Div., S.G.O.).
- ¹³Supra., p. 103.
- ¹⁴Supra., p. 103.
- ¹⁵Supra., p. 18.

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- 16 McKinney, op. cit., p. 45.
- 17 Medical Department Research Program, Fiscal Year 1941, 3 Apr. 1941, CONFIDENTIAL, p. 39 (Rec. Rm., S.G.O. 700.2-1). Extracted in clear. Inasmuch as our interest in administrative procedure relating to project initiation does not extend to the period prior to 1940, no attempt will be made to discuss the question of Medical Department conformance in this instance with AR 850-25.
- 18 Memo. to M.D. Bd., fr. M.D.E.L., 11 Oct. 1939; subject: "Gold Medal Folding Litter," pp. 1-2 (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 19 Ibid., p. 2.
- 20 S.G.O. Circular Letter No. 3, 23 Mar. 1937.
- 21 Litter Procurement Records (Supply Service, S.G.O.).
- 22 Infra., pp. 126-129.
- 23 Ltr. to CG, Carlisle Barracks, Pa., fr. S.G.O., 29 Mar. 1939; subject: "Gran Portable Stretcher" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 24 1st Ind. to S.G.O., fr. Hq., M.F.S.S., 4 Apr. 1939; basic: see n. 23 (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 25 Ltr. to M.D. Bd., fr. M.D.E.L., 19 Jul. 1939; subject: "Tests of the Gran and Schwichtenberg Litters" (M.D.E.L.).
- 26 Rpt. of M.D. Bd., M.F.S.S., 24 Jul. 1939; subject: "Litter, portable, Gran" (M.D.E.L.).
- 27 Ibid., pp. 1-2.
- 28 Ibid., p. 2.
- 29 Ltr. to Dr. A.G. Gran, Storm Lake, Iowa, fr. S.G.O., 31 Jul. 1939 (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 30 1st Ind. to S.G.O., fr. The Surgeon General, Wright Field, Dayton, Ohio, 6 May 1939; basic: ltr. to S.G.O., fr. A.H. Schwichtenberg, Capt., M.C., Station Dispensary, Wright

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Field, Office of the Flight Surgeon, 5 May 1939; subject: "New Type Steel Tube Litter" (M.D.E.L.).

³¹See n. 25, p. 161.

³²Rpt. of M.D. Bd., M.F.S.S., 24 Jul. 1939; subject: "Litter, Steel Tube, New Type" (Capt. Schwichtenberg) (M.D.E.L.).

³³Ibid., pp. 1-2.

³⁴Ibid., p. 2.

³⁵Ltr. to Medical Section, War Dept., fr. Gold Medal Folding Furniture, Racine, Wisc., 20 Sep. 1939 (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).

³⁶Ltr. to The Commandant, M.F.S.S., fr. M.D.E.L., 11 Oct. 1939; subject: "Gold Medal Folding Litter" (Rec. Rm.; S.G.O. 442.-7 Carlisle Bks.-N).

³⁷Ibid., p. 1.

³⁸Ibid., p. 2.

³⁹Ltr. to The Commandant, M.F.S.S., fr. S.G.O., 3 Apr. 1940; subject: "Folding Litter: modification of Army type" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).

⁴⁰1st Ind. to S.G.O., fr. The Commandant, M.F.S.S., 9 May 1940; basic: ltr. to CO, M.F.S.S., fr. S.G.O., 4 May 1940; subject: "Folding Litter: modification of Army Type" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-7).

⁴¹Ltr. to The Commandant, M.F.S.S., fr. S.G.O., 4 May 1940; subject: "Folding Litter: modification of Army Type" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).

⁴²Memo. to Chf., Finance & Supply Div., S.G.O., fr. Planning & Training Div., S.G.O., 6 Jun. 1940; subject: "Folding Litters" (A.M.R. & D. Bd.).

⁴³Supra., p. 20.

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- 44 1st Ind. to Office of Chf. of Air Corps, fr. S.G.O., 10 Jun. 1940; basic: see n. 42 (A.M.R. & D. Bd.).
- 45 2d Ind. to S.G.O., fr. Chf., Medical Div., Air Corps, 19 Jun. 1940; basic: see n. 42 (A.M.R. & D. Bd.).
- 46 1st Ind. to Finance & Supply Div., S.G.O., fr. Planning & Training Div., S.G.O., 28 Jun. 1940; basic: memo. to Planning & Training Div., S.G.O., fr. Finance & Supply Div., S.G.O., 24 Jun. 1940; subject: "Folding Litters" (A.M.R. & D. Bd.).
- 47 Infra., p. 121.
- 48 Rpt. of M.D. Bd., 1 Jul. 1940 (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N). The Description of the Zimmer litter and the experience of the 1st Medical Regiment are also taken from the above report.
- 49 Ibid., pp. 3-4.
- 50 Ltr. to President, M.D. Bd., fr. S.G.O., 10 Jul. 1940; subject: "Folding Litter, Zimmer Type" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 51 1st Ind. to Finance & Supply Div., S.G.O., fr. Planning & Training Div., S.G.O., 28 Jun. 1940; basic: memo. to Planning & Training Div., S.G.O., fr. Finance & Supply Div., S.G.O., 24 Jun. 1940; subject: "Folding Litters" (A.M.R. & D. Bd.).
- 52 Medical Department Research Program, Fiscal Year 1941, 3 Apr. 1941, CONFIDENTIAL, p. 39 (Rec. Rm., S.G.O. 700.2-1).
Extracted in clear.
- 53 Ibid., p. 39.
- 54 Monthly Progress Report, M.D.E.L., Feb., 1942, p. 6.
(M.D.E.L.)
- 55 FM-35, Transportation of the Sick and Wounded, Feb., 1945, pp. 188-206.
- 56 Ltr. to S.G.O., fr. Chf., Supply Div., Air Surgeon's Office, Hq., A.A.F., 4 Feb. 1944 (A.M.R. & D. Bd.).
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- 57 Supra., p. 118.
- 58 Ltr. to The Commandant, M.F.S.S., fr. S.G.O., 18 Sep. 1940; subject: "Retest of Zimmer Folding Litter, new model" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 59 Ltr. to CO, Provisional Medical Battalion, Carlisle Barracks, Pa., fr. M.D.E.L., 24 Sep. 1940; subject: "Test of Zimmer Manufacturing Company Folding Litter (New Type)" (M.D.E.L.).
- 60 Ltr. to The President, M.D. Bd., fr. M.D.E.L., 2 May 1941; subject: "Zimmer Folding Litter, New Model," pp. 1-3 (M.D.E.L.).
- 61 Ltr. to M.D.E.L., fr. 32d Medical Bn. (Separate), 4 Oct. 1940; subject: "Report of Test of Zimmer Manufacturing Company Folding Litter (New Type)", pp. 1-3 (M.D.E.L.).
- 62 See n. 60, above.
- 63 Rpt. of M.D. Bd., 4 Jun. 1941; subject: "Project No. 192, Zimmer Folding Litter, New Model" (M.D.E.L.).
- 64 U.S. Army Specification No. 10-2994, 28 Aug. 1941 (Supply Service, S.G.O.).
- 65 Litter Procurement Records (Supply Service, S.G.O.).
- 66 Medical Department Tentative Specification No. 389-E (Supply Service, S.G.O.).
- 67 Ltr. to S.G.O., fr. Air Service Command, 25 Mar. 1942; subject: "Litters" (Rec. Rm., S.G.O. 442.-7).
- 68 Ltr. to S.G.O., fr. Chf., Supply Div., Air Corps, 22 May 1942; subject: "Litters, Aluminum Folding, Medical Department Catalog No. 99380" (Rec. Rm., S.G.O. 442.-7 Carlisle Bks.-N).
- 69 4th Ind. to S.G.O., fr. M.D.E.L., 23 Jun. 1942; basic: memo. to Procurement Div., S.G.O., fr. Hq., Air Service Command, 29 May 1942; subject: "Litters" (Rec. Rm., S.G.O. 442.-7).

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- 70 3rd Ind. to M.D.E.L., fr. S.G.O., 17 Jun. 1942; basic: memo. to Procurement Div., S.G.O., fr. Hq., Air Service Command, 29 May 1942; subject: "Litters" (Rec. Rm., S.G.O. 442.-7).
- 71 9th Ind. to Medical Supply Div., A.A.F., fr. S.G.O., 24 Jul. 1942; basic: memo. to Procurement Div., S.G.O., fr. Hq., Air Service Command, 29 May 1942; subject: "Litters" (Rec. Rm., S.G.O. 442.-7).
- 72 Supra., pp. 115-116.
- 73 AR 850-25, Sec. 4, 23 Jul. 1936.
- 74 1st Ind. to S.G.O., fr. M.D.E.L., 16 Aug. 1943; basic: (not on file) (A.M.R. & D. Bd.).
- 75 Supra., p. 111.
- 76 Ltr. to Dr. A.G. Gran, Storm Lake, Ia., fr. S.G.O., 31 Jul. 1939 (Rec. Rm., S.G.O. 442.-7).
- 77 Ltr. to Honorable Guy M. Gillette, U.S. Senate, fr. S.G.O., 18 Sep. 1941 (Rec. Rm., S.G.O. 442.-7).
- 78 Ibid.
- 79 Ltr. to S.G.O., fr. Honorable Clyde L. Herring, U.S. Senate, 12 Sep. 1941 (Rec. Rm., S.G.O. 442.-7).
- 80 Ltr. to Honorable Clyde L. Herring, U.S. Senate, fr. S.G.O., 15 Sep. 1941 (Rec. Rm., S.G.O. 442.-7).
- 81 Ltr. to The Surgeon General, fr. Honorable Guy M. Gillette, U.S. Senate, 15 Sep. 1941 (Rec. Rm., S.G.O. 442.-7).
- 82 Ltr. to Honorable Guy M. Gillette, U.S. Senate, fr. S.G.O., 18 Sep. 1941 (Rec. Rm., S.G.O. 442.-7).
- 83 Ltr. to S.G.O.; fr. Gran Laboratories, Dr. A.G. Gran, Storm Lake, Ia., 14 Oct. 1941 (Rec. Rm., S.G.O. 442.-7).

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- 84 Ltr. to Dr. A.G. Gran, Storm Lake, Ia., fr. S.G.O.,
20 Oct. 1941 (Rec. Rm., S.G.O. 442.-7).
- 85 Ltr. to The Surgeon General, fr. Dr. Albert G. Gran, Storm
Lake, Ia., 22 Nov. 1941 (Rec. Rm., S.G.O. 442.-7).
- 86 Ltr. to Dr. A.G. Gran, Gran Laboratories, Storm Lake, Ia.,
fr. S.G.O., 28 Nov. 1941 (Rec. Rm., S.G.O. 442.-7).
- 87 Ltr. to S.G.O., fr. Gran Laboratories, Dr. Albert G. Gran,
Storm Lake, Ia., 11 Dec. 1941 (Rec. Rm., S.G.O. 442.-7).
- 88 Ltr. to Dr. Albert G. Gran, Gran Laboratories, Storm Lake,
Ia., fr. S.G.O., 19 Dec. 1941 (Rec. Rm., S.G.O. 442.-7).
- 89 Memo. to Inspector General's Dept., fr. S.G.O., 31 Mar.
1942 (Rec. Rm., S.G.O. 442.-7).
- 90 Ltr. to Office of Civilian Defense, fr. S.G.O., 7 Apr. 1942;
subject: "Gran Portable Litter for Civilian Defense" (Rec.
Rm., S.G.O. 442.-7).
- 91 Ltr. to War Dept., fr. Honorable Guy M. Gillette, U.S.
Senate, 7 Jan. 1944 (Rec. Rm., S.G.O. 442.-7).
- 92 Ltr. to Honorable Guy M. Gillette, U.S. Senate, fr.
Administrative Asst. to Secy. of War, 24 Jan. 1944
(Rec. Rm., S.G.O. 442.-7).
- 93 Ltr. to Senator Guy M. Gillette, fr. Gran Laboratories,
Albert G. Gran, M.D., Storm Lake, Ia., 26 Jun. 1944 (Rec.
Rm., S.G.O. 442.-7).
- 94 Draft of ltr. to Honorable Guy M. Gillette, U.S. Senate,
fr. Administrative Asst. to Secy. of War, undated
(A.M.R. & D. Bd.).
- 95 Ltr. to Finance & Supply Div., S.G.O., fr. Planning &
Training Div., S.G.O., 19 May 1941; subject: "Experimental
Litter" (Rec. Rm., S.G.O. 442.-7).
- 96 Ltr. to The Brumor Corp., N.Y.C., fr. S.G.O., 19 Feb. 1941
(Rec. Rm., S.G.O. 442.-7).

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- 97 Memo. to Brumor Corp., N.Y.C., fr. S.G.O., 27 May 1941 (Rec. Rm., S.G.O. 442.-7).
- 98 Ltr. to CO, 32d Medical Bn., fr. M.D.E.L., 1 Aug. 1941; subject: "Test of the Brumor Folding Litter as a Substitute for Standard Folding Litter" (M.D.E.L.).
- 99 Ltr. to S.G.O., fr. M.D.E.L., 2 Sep. 1941; subject: "Test of the Brumor Folding Litter" (M.D.E.L.).
- 1 Ltr. to M.D.E.L., fr. 32d Medical Bn., 18 Aug. 1941; subject: "Testing of Brumor Folding Litter" (M.D.E.L.).
- 2 See n. 99, above.
- 3 Ltr. to M.D.E.L., fr. United Metal Box Co., Brooklyn, N.Y., 8 Jun. 1942 (M.D.E.L.).
- 4 Ltr. to CO, 32d Medical Bn., fr. M.D.E.L., 9 Jul. 1942; subject: "Test of Folding Litter" (M.D.E.L.).
- 5 Ibid.
- 6 Ltr. to M.D.E.L., fr. 32d Medical Bn., 24 Jul. 1942; subject: "Test, Steel Pole Collapsible Litter" (M.D.E.L.).
- 7 Ltr. to United Metal Box Co., Brooklyn, N.Y., fr. M.D.E.L., 28 Jul. 1942 (M.D.E.L.).
- 8 Ibid.
- 9 Ltr. to Asst. Chf. of Staff, G-2, fr. Military Attache, American Legation, Bern, Switzerland, 5 Nov. 1941; subject: "The Koller 1-man and 2-man metal rod stretchers" (Rec. Rm., S.G.O. 442.-7).
- 10 2d Ind. to Asst. Chf. of Staff, G-2, fr. S.G.O., 4 Dec. 1941; basic: see n. 9 (Rec. Rm., S.G.O. 442.-7).
- 11 Ltr. to M.D.E.L., fr. S.G.O., 2 Jun. 1942; subject: "Stretcher" (M.D.E.L.).
- 12 Ltr. to CO, 32d Medical Bn., fr. M.D.E.L., 20 Jun. 1942; subject: "Stretcher (Koller Litter and Koller Pack Litter)" (M.D.E.L.).

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- 13 Heflebower, op. cit., p. 8.
- 14 Ltr. to Army Ordnance Dept., fr. Alfred Sonder, New York, N.Y., 6 Apr. 1942 (Rec. Rm., S.G.O. 442.-7)
- 15 Ltr. to M.D.E.L., fr. 32d Medical Bn., 7 Jul. 1942; subject: "Report of Test, Koller Litter & Koller Pack Litter" (M.D.E.L.).
- 16 Ltr. to S.G.O., fr. M.D.E.L., 3 Aug. 1942; subject: "Stretcher (Koller Litter and Koller Pack Litter)" (M.D.E.L.).
- 17 Ltr. to S.G.O., fr. Alfred Sonder, New York, N.Y., 11 Aug. 1942 (M.D.E.L.).
- 18 Ltr. to S.G.O., fr. Alfred Sonder, New York, N.Y., 5 Aug. 1942 (M.D.E.L.).
- 19 Ltr. to M.D.E.L., fr. S.G.O., 15 Aug. 1942; subject: "Test of Improved Model Stretcher" (M.D.E.L.).
- 20 Ltr. to S.G.O., fr. M.D.E.L., 24 Oct. 1942; subject: "Koller Stretcher" (M.D.E.L.).
- 21 Ltr. to Alfred Sonder, New York, N.Y., fr. S.G.O., 18 Sep. 1942 (Rec. Rm., S.G.O. 442.-7).
- 22 Memo. to Gen. Addison D. Davis, Post Hq., Calisles Barracks, Pa., fr. Dir. M.D.E.L., 12 Mar. 1943 (M.D.E.L.).
- 23 Memo. by J. H. Bailey, Col., A.D.M.S., 52d Div., Great Britain, 24 Oct. 1942 (A.M.R. & D. Bd.).
- 24 See Development Project, F-34 "Litter, Mountain" (A.M.R. & D. Bd.).
- 25 Supra., pp. 54-57.
- 26 Ltr. to S.G.O., fr. Tech. Dev. Sec., W.P.B., Chicago, Ill., 8 Dec. 1942; subject: "Stretcher-Army Cot" (Rec. Rm., S.G.O. 442.-7).
- 27 Ltr. to Tech. Dev. Sec., W.P.B., Chicago, Ill., fr. S.G.O., 15 Dec. 1942; subject: "Stretcher-Army Cot" (Rec. Rm., S.G.O. 442.-7).

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- 28 Memo. to Office of Under Secy. of War, Materials Div., Resources Br., fr. S.G.O., 6 Mar. 1942; subject: "Conservation of Aluminum" (A.M.R. & D. Bd.). Also see ltr. to Aluminum Co. of America, Phila., Pa., fr. M.D.E.L., 21 Feb. 1942 (M.D.E.L.).
- 29 Ltr. to Aluminum Co. of America, Phila., Pa., fr. M.D.E.L., 21 Feb. 1942 (M.D.E.L.).
- 30 Ltr. to Zimmer Splint Co., N.Y.C., fr. M.D.E.L., 21 Feb. 1942 (M.D.E.L.).
- 31 Ltr. to M.D.E.L., fr. Aluminum Co. of America, Phila., Pa., 25 Feb. 1942 (M.D.E.L.).
- 32 Ltr. to M.D.E.L., fr. Zimmer Splint Co., N.Y.C., 25 Feb. 1942 (M.D.E.L.).
- 33 Ltr. to Zimmer Splint Co., N.Y.C., fr. M.D.E.L., 28 Feb. 1942 (M.D.E.L.).
- 34 Ltr. to M.D.E.L., fr. Zimmer Splint Co., N.Y.C., 2 Mar. 1942 (M.D.E.L.).
- 35 Ltr. to S.G.O., fr. Supply Div., Air Corps, 22 May 1942; subject: "Litters, Aluminum, Folding, Medical Dept. Cat. No. 99380" (Rec. Rm., S.G.O. 442.-7).
- 36 Ibid.
- 37 Ltr. to S.G.O., fr. Zimmer-Thomson Corp., Long Island City, N.Y., 15 Feb. 1943 (Rec. Rm., S.G.O. 442.-7).
- 38 Ltr. to M.D.E.L., fr. Zimmer-Thomson Corp., Long Island City, N.Y., 15 Feb. 1943 (M.D.E.L.).
- 39 Ibid., p. 2.
- 40 Ibid., p. 1.
- 41 Ibid., p. 1.
- 42 Ltr. to CO, 32d Medical Bn., fr. M.D.E.L., 5 Mar. 1943; subject: "Test of Folding Litters" (M.D.E.L.).

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- ⁴³Ltr. to M.D.E.L., fr. 32d Medical Bn., 10 Mar. 1943; subject: "Test of Experimental Litters" (M.D.E.L.).
- ⁴⁴Ibid., p. 1.
- ⁴⁵Ltr. to S.G.O., fr. M.D.E.L., 16 Mar. 1943; subject: "Litter, Double-Fold, Laminated, Wooden Pole" (M.D.E.L.).
- ⁴⁶Signed statement by E.D. Quinnell, Col., M.C., Dir., M.D.E.L., rec'd by Hist. Div., S.G.O., 1 Oct. 1945 (Hist. Div., S.G.O.).
- ⁴⁷Ibid.
- ⁴⁸See n. 42, p. 169.
- ⁴⁹See n. 45, above.
- ⁵⁰See n. 46, above.
- ⁵¹Ltr. to CO, N.Y. Medical Dept. Procurement District: (Attn: Production Control Officer), fr. Chf., Field Equipment Br., Plans Div., S.G.O., 1 Jul. 1943; subject: "Development Cost for Laminated Wood Pole Litter" (A.M.R. & D. Bd.).
- ⁵²See n. 42, p. 169.
- ⁵³FM 8-35, Transportation of the Sick and Wounded, Feb., 1945, pp. 42-43.
- ⁵⁴Ibid.
- ⁵⁵See n. 43, above.
- ⁵⁶Ibid., p. 1.
- ⁵⁷Ltr. to S.G.O., fr. M.D.E.L., 16 Mar. 1943; subject: "Litter Double Fold, Laminated, Wooden Pole" (M.D.E.L.).
- ⁵⁸Ibid.
- ⁵⁹Ltr. to S.G.O., fr. Distribution Sec., Hq., A.A.F., 6 Apr. 1943; subject: "Double Fold, Ply Wood Pole Litters" (A.M.R. & D. Bd.).

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- 60 1st Ind. to S.G.O., fr. Material Div., A.A.F., 22 Apr. 1943;
basic: Ltr. to Aero Medical Research Lab., Wright Field,
fr. Distribution Sec., A.A.F., 6 Apr. 1943; subject: "Double
Fold, Ply Wood Pole Litters" (A.M.R. & D. Bd.).
- 61 Supra., pp. 70-74.
- 62 Ltr. to S.G.O., fr. Mikar Specialties Co., Baltimore, Md.,
16 Jun. 1943 (Rec. Rm., S.G.O. 442.-7).
- 63 Memo. to Under Secy. of War, fr. S.G.O., 4 Feb. 1943 (Rec.
Rm., S.G.O. 442.-7).
- 64 Ltr. to S.G.O., fr. Hq., A.A.F., 16 Mar. 1943; subject:
"Litter, Straight Pole, Laminated Wood" (A.M.R. & D. Bd.).
- 65 S.G.O. Circular Letter 103, 15 May 1943.
- 66 Supra., p. 147.
- 67 1st Ind. to Hist. Div., S.G.O., fr. A.M.P.O., 25 Jan. 1945;
basic: ltr. to A.M.P.O., fr. Hist. Div., S.G.O., 22 Jan.
1945 (Hist. Div., S.G.O.).
- 68 Ibid.
- 69 Procurement Status Report of 30 Sep. 1943, prepared by C.E.
Graham Reeves (A.M.R. & D. Bd.).
- 70 1st Ind. to Hist. Div., S.G.O., fr. A.M.P.O., 25 Jan. 1945;
basic: ltr. to A.M.P.O., fr. Hist. Div., S.G.O., 22 Jan.
1945 (Hist. Div., S.G.O.).
- 71 Robinson, op. cit., p. 6.
- 72 Ltr. to Army Ground Forces; (Attn: Ground Surgeon), fr. S.G.O., 5 Apr
1944; subject: "Litters" (Rec. Rm., S.G.O. 442.-7).
- 73 Min. of M.D.T.C., 23 Jul. 1945, p. 3 (Hist. Div., S.G.O.).
- 74 1st Ind. to Hist. Div., S.G.O., fr. A.M.P.O., 25 Jan. 1945;
basic: ltr. to A.M.P.O., fr. Hist. Div., 22 Jan. 1945
(Hist. Div., S.G.O.).

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75 Supra., p. 74.

76 Ltr. to Army Ground Forces; (Attn: Ground Surgeon), fr. S.G.O., 5 Apr. 1944; subject: "Litters" (Rec. Rm., S.G.O. 442.-7)

77 See n. 73.

78 Ltr. to CG, Army Ground Forces, fr. Amphibious Training Command, U.S. Atlantic Fleet, Naval Operating Base, Norfolk, Va., 2 Feb. 1944; subject: "Use of the Folding Wood Litter with the Collapsible Field Carrier" (M.D.E.L.).

79 1st Ind. to S.G.O., fr. M.D.E.L., 19 Apr. 1944; basic: memo. to M.D.E.L., fr. S.G.O., 23 Feb. 1944; subject: "Litter, Folding Wood" (M.D.E.L.).

80 2d Ind. to CG, Army Service Forces, fr. S.G.O., 25 Apr. 1944; basic: memo. to M.D.E.L., fr. S.G.O., 23 Feb. 1944; subject: "Litter, Folding Wood" (A.M.R. & D. Bd.).

81 Ltr. to S.G.O., fr. Hq., A.A.F., 4 Feb. 1944; subject: "Item No. 99350, Litter, Straight, Aluminum" (Rec. Rm., S.G.O. 442.-7).

82 FM 8-35, Transportation of the Sick and Wounded, Feb., 1945, pp. 192-204.

83 Ibid., p. 201.

84 Memo. to Field Equipment, Dev. Br., S.G.O., fr. Research Coordination Br., S.G.O., 5 Jul. 1943 (A.M.R. & D. Bd.).

85 1st Ind. to S.G.O., fr. M.D.E.L., 8 Jul. 1943; basic: memo to Field Equipment Dev. Br., S.G.O., fr. Research Coordination Br., S.G.O., 5 Jul. 1943 (A.M.R. & D. Br.).

86 Min. of M.D.T.C., Meeting No. 8, RESTRICTED, 19 Jul. 1943. Extracted in clear.

87 Memo. to Field Equipment Dev. Br., Plans Div., S.G.O., fr. Research Coordination Br., Plans Div., S.G.O., 26 Jul. 1943; subject: "Folding Litter - Suspension of Development Project on" (A.M.R. & D. Bd.).

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88 See n. 60, p. 171.

89 Report on Medical Research and the Development and Classification of Medical Department Items of Supply and Equipment, 4 Dec. 1943. Document appended to Annual Report of Research Coordination Branch, Technical Division, S.G.O., for Fiscal Year ending 30 Jun. 1944 (Hist. Div., S.G.O.).

90 At first glance it might seem that the relationship with Mikar Specialties Company could be cited as an exception to this statement. It will be recalled, however, that the difficulties encountered here arose after development work had been completed. Such disagreement as existed between the Equipment Laboratory and the Field Equipment Branch of the Plans Division, S.G.O., grew out of their differing evaluations of the services performed by this manufacturer.

91 Ltr. to CG, A.S.F., fr. S.G.O., 18 Aug. 1944; subject: "Item 9935000, Litter, Straight, Aluminum and Item 9938000, Litter, Folding Aluminum" (Rec. Rm., S.G.O. 442.-7).

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CHAPTER IV

MISCELLANEOUS LITTERS AND LITTER ADAPTERS

Section 1

Development Project, F-28

Litter, Ski

I. Introduction.

In Alpine, low mountain, and other cold weather zones where casualties must be transported over icy trails and through deep snow, the evacuation of litter patients from forward areas by conventional hand carry methods is a precarious and awkward operation. To begin with, there are certain mechanical difficulties. Since neither of the standard Medical Department litters, the straight or folding pole, was specifically designed for use under severe winter conditions, certain structural changes are unavoidably necessary. Yet, once instituted, these changes give rise to a series of new problems. For example, two-man carry is virtually impossible over ice-covered terrain unless litter poles are so lengthened that the rear man can see far enough ahead to keep his balance.¹ Increasing the length of the poles, however, adds to the over-all weight of the litter, and this in turn increases the burden on the bearers. Furthermore, unless the material from which the side poles are constructed possesses a high degree of rigidity, adding to pole length will tend to increase the amount of "patient bounce", with perhaps serious effect upon the casualty.²

Though these mechanical difficulties are reduced by the substitution of four-man litter teams, they are by no means eliminated. Moreover, and this is an even more serious disadvantage, regardless of whether two or four-man teams are used, a litter haul over slippery, snow-packed terrain can be effectively accomplished only if all bearers are equipped with snow shoes. The point does not need elaboration that manual carry under these conditions is fatiguing in the extreme, and cannot be performed at all without frequent and adequate rest periods.³ Not only, therefore, is the rate of bearer-replacement excessive, but the entire front-line evacuation procedure becomes dangerously time-consuming. It is, in short, this latter factor--the excessive slowness of the hand carry method--which definitely precludes its routine employment in winter warfare; for in cold weather operations, one of the cardinal obligations of the Medical Department is the speedy evacuation of

the wounded to places where they can be kept warm and sheltered.⁴

A. The Emergency Ski-Sled.

One of the earliest field improvisations to be designed as a substitute for the hand carry method of evacuation was the emergency ski-sled. Instructions for the assembly of this item were as follows. Two skis were placed on the snow, parallel to each other and one rucksack width apart. Contraction bands were slipped under each ski, approximately 18 inches from the tip and heel respectively. Two rucksack frames were then removed from their carriers and placed on the skis in such a manner that the bases of the frames rested on the upper surface of the skis just above the contraction bands. The upper parts of the frames, which nearly met above the ski bindings, were lashed together and reinforced with ski poles or sticks. Small metal adapters held the frames securely to the contraction bands, and, on the upper surface of the frames, a second pair of skis were lashed, face-downward, to form a carrying platform.⁵

While this improvised ski-sled had the advantages of speed and ease of movement, it also possessed a number of disadvantages.⁶ In order to use the sled for evacuation, it was necessary to lash the casualty tightly to the carrying platform. It was difficult to accomplish this without, at the same time, cutting off the patient's flow of circulation. Moreover, as a protection against the rough surface of the platform and against the cold coming up from below, especially heavy padding had to be placed under the patient. Furthermore, a considerable amount of equipment was needed for the improvisation, the complete unit consisting of 4 pairs of adapters, 4 contraction bands, 2 pairs of skis, and 2 rucksack frames. Finally, since the ski-sled was not adaptable to the fittings in ground and air ambulances, the casualty had to be moved to a standard Medical Department litter before he could be transported through the rear echelons of the chain of evacuation.

B. The 1935 Ski Litter Adaptation.

In 1935 the Medical Department Equipment Laboratory assembled for the Air Corps, for examination and field trial by its Winter Test Group, an "Arctic Rescue Unit, Experimental." Included in this unit was a new type of ski litter adaptation. The assembly (see Fig. 14) consisted of a Carlisle model folding litter and standard Quartermaster skis fitted with permanent ski attachments which fastened onto the stirrups of the litter.⁷ The adapter was essentially a metal clamp which was

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bolted to the upper surface of the skis. While this experimental device was never formally adopted as a standard Medical Department item,⁸ it had a practical as well as historical importance in that it pointed the way to an entirely new principle of construction. In subsequent years this design was to furnish the starting point for Development Project, F-28.

Compared with the emergency ski sled, the new ski litter possessed a number of decided advantages. It was an equally speedy means of evacuation and, at the same time, afforded a safer and much more comfortable ride. Standard litter securing straps, without impeding the free flow of circulation, held the patient firmly on the bed of the litter. Moreover, once placed on the regulation folding litter, which had been adapted to the interior fittings of all Medical Department vehicles, the casualty could be carried uninterruptedly through the entire chain of evacuation. Finally, one special set of skis with built-in adapters was the only additional equipment required; in contrast to the 12 assorted items required to assemble the emergency ski sled.

In one respect, however, the earlier ski sled design suggested a way in which the new ski litter could be materially improved. In the sled assembly, it will be recalled, the contraction bands and metal adapters which held the rucksack frames to the surface of the skis were detachable. If, therefore, instead of permanent attachments a one-piece detachable clamp could be devised which would hold the litter and skis together, special sets of prepared skis would no longer be necessary. In that event, aside from the litter itself, all the medical corpsman would have to carry would be several sets of small metal clamps. The pair of skis needed for the conversion could be obtained, quite simply, from the casualty.

This logical next step, the development of a detachable ski clamp, was, as we shall see, the specific purpose of the formal research project, "F-28", which was initiated by the Medical Department in 1943.

II. Preliminary Phase.

A. Project Initiation.

Tables of Organization, establishing the Medical Battalion (Mountain Division), were published by the War Department on 1 April 1942.⁹ However, the initial Tables of Equipment for the new organization contained little in the way of specialized evacuation aids. Accordingly, on 21 May 1942, in a communication addressed to The Surgeon General's Office, the Medical

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Department Equipment Laboratory requested authorization to establish a group of development projects designed to provide more adequate means for the emergency evacuation of wounded in mountain and winter warfare. Among the research projects which were proposed was one entitled, "Medical Equipment for Ski Troops", for which a \$3,000 allocation of funds was requested for the Fiscal Years 1943 and 1944.¹⁰ This action, it appears from the evidence at hand, marked the beginning of the World War II history of the ski litter.

While it is not clear whether its action was taken independently or in response to the recommendations made by the Equipment Laboratory, in June 1942, the Hospital and Evacuation Division of Army Ground Forces wrote to The Surgeon General's Office, asking for detailed information regarding the immediate availability or, lacking that, the development status of certain specified items pertaining to the medical evacuation of mountain troops. The mountain litter was one of five items on which this information was requested.¹¹ The inquiry was forwarded to the Equipment Laboratory which replied on 22 June 1942 that no standard items of equipment corresponding to those listed in the basic communication were then available, but that it was the opinion of the Laboratory that these items could be successfully developed. After mention of various improvisations that had been attempted, attention was called to the project recommendations which had recently been submitted by the Laboratory on the subject of mountain equipment for medical units.¹²

This reply was forwarded to Army Ground Forces on 30 June 1942, but no further action appears to have been taken until shortly before the close of the year. On 8 December 1942, Army Ground Forces notified The Surgeon General's Office informally that a military requirement for a mountain litter now existed, and suggested that a development project to produce such an item be initiated.¹³ Inasmuch as no specification was made as to the type of mountain litter desired, the Director of the Research and Development Division, Surgeon General's Office, in a letter to the Plans Division, prescribed that the development be initiated by one of the following two methods:

- a. Request Headquarters, Army Ground Forces, to designate appropriate unit for service test of pilot model of Carlisle "Arctic Rescue Unit, Air Corps (experimental) Model December 1935".
- b. Request Medical Department Equipment Laboratory, Carlisle Barracks, Pennsylvania, to initiate new project F-28 "Medical Equipment for Mountain Troops".¹⁴

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It was further recommended that the Plans Division designate a representative to visit the Mountain and Winter Warfare Board and the Mountain Training Center at Camp Hale, Colorado, with the view of determining more exactly the needs of the units for which this special evacuation equipment was to be designed.¹⁵

Apparently, however, this latter recommendation was not followed. Instead, a conference was held at The Surgeon General's Office on 22 February 1943, to achieve the needed clarification of research objectives. On this occasion the Director of the Medical Department Equipment Laboratory was present to discuss, "Cold Weather Operations and Application of Medical Equipment to Such Operations," and presented a detailed study of the problems of medical evacuation under snow and ice conditions generally, and also with respect to the special needs of light Alpine divisions. In the course of this discussion, ski clamps were declared to be essential equipment for mountain divisions, and the specific situations requiring their use were described at some length.¹⁶

Five days after the conclusion of the above conference, the Equipment Laboratory submitted a formal request for project initiation. The complete text of the document follows.

1. It is believed desirable to set up a project on development of sleds and other means of transport for winter warfare.
2. The funds necessary should be approximately \$1,000.¹⁷

Apparently it was the Laboratory's idea to combine several of the items of mountain equipment proposed for development into a single research project. In any event, in view of the extensive provisions of AR 850-25 on the subject of project initiation, the information given was inadequate. Accordingly, the Research and Development Division replied by requesting: (1) a clear segregation of all the various items to be developed; (2) a more specific and complete statement on each individual item proposed; (3) reconsideration as to the sufficiency of the funds requested.¹⁸

In accordance with the above instructions the original project request was expanded and rewritten, and a new draft was submitted by the Equipment Laboratory on 8 March 1943. This time Development Project, F-28, "The Ski Litter", was completely segregated from other research activities. Its purpose was carefully defined as follows:

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To determine the feasibility of the conversion or adaptation of standard litters to standard skis for use as a sled for the evacuation of wounded over terrain covered with ice and snow.¹⁹

In addition, a complete list of military characteristics was presented. Inasmuch as this statement of military characteristics was subsequently adopted without change by higher authority, it will be quoted here in full.

- (1) That the ski litter be an adaptation or conversion of the standard litter and the standard ski by means of an attachment.
- (2) That the attachment for this conversion or adaptation be so designed that it will provide the following:
 - (a) A positive means of securing the litter stirrups to the skis.
 - (b) Construction and design to provide for ease of assembling and disassembling.
 - (c) To be of light weight and of sturdy construction.
 - (d) To be inexpensive and easy to procure.²⁰

Finally, it was requested that the sum of \$200 be authorized to cover development costs.²¹

On the basis of the above data, informal approval of Army Service Forces for initiation of the ski litter project was obtained 13 March 1943. The only change made in the Laboratory's proposals was an increase in research funds from \$200 to \$1,000.²² On 19 March 1943, the Laboratory was notified that preliminary Army Service Forces approval had been secured and, since only routine processing procedures remained to be accomplished, authority was given to initiate work on the project immediately.²³

Formal processing of the initiation request was completed in approximately two months. In contrast to the administrative omissions previously noted in connection with the establishment of the straight and folding pole litter projects, in the present instance all procedural steps required by Army Regulations were scrupulously followed. On 14 April 1943, the Subcommittee of the Medical Department Technical Committee recommended that a research project to develop a ski litter for use in snow and ice country be established, and that the military characteristics of the proposed item as outlined in the report of the Equipment Laboratory be

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approved.²⁴ The Medical Department Technical Committee, with six representatives of Army Ground Forces present and voting, concurred unanimously in the Subcommittee recommendations on 10 May 1943.²⁵ Final official approval was obtained from Headquarters, Army Service Forces, on 21 May 1943,²⁶ and ten days later all interested agencies within The Surgeon General's Office were formally notified of the initiation of the new development project.²⁷

Exactly one year had elapsed from the time the project had first been proposed by the Medical Department Equipment Laboratory to its final acceptance by Headquarters, Army Service Forces. Actually, however, only a fraction of the total delay could be ascribed directly to the Medical Department. Almost six months had been spent in waiting for Army Ground Forces to submit the statement that a definite military requirement existed for the proposed item. When this statement was finally received by The Surgeon General's Office, it was still necessary to translate the general request for a "mountain litter" into a specific project proposal acceptable to the approving authorities. This, it will be recalled, was accomplished by the Medical Department in less than three months. It should also be added that authorization to begin development work had been granted to the Equipment Laboratory fully sixty days before the expiration of the full twelve-month period.

As we shall see presently, coordination difficulties with Army Ground Forces were not to be confined solely to the preliminary stages of this project. Nor were delays, at times as lengthy as those described above, successfully avoided in the later stages of research activity. For, although the estimated completion date for Development Project, F-28 was originally set for 1 September 1943,²⁸ the project was not actually terminated until 15 January 1945.²⁹ The extent to which faulty coordination between the Medical Department and Army Ground Force installations was responsible for this situation may be judged from the account that follows.

B. Pre-Development Activity.

A great deal more was accomplished by Medical Department research and development personnel during the period, 21 May 1942 to 21 May 1943, than mere routine conformance with the procedural requirements of AR 850-25. Scientific background material was collected and classified; other litter models, developed in connection with such projects as F-7 and F-11, were carefully studied to discover possible applications for the new research undertaking; correspondence was initiated with key officers at mountain training installations and with commercial firms; Quartermaster ski equipment was requisitioned;

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small-scale laboratory investigation was begun. In short, despite the fact that formal project initiation was to take nearly a year, no time was being lost in getting research preliminaries well under way.

Early in May, 1942--before, in fact, the first request for establishment of a ski litter project had been submitted by the Equipment Laboratory--The Surgeon General's Office had entered into correspondence with Dr. Whitman Mead Reynolds, a Connecticut physician who had devoted considerable time to the study of the medical aspects of mountain warfare.³⁰ As an outgrowth of this correspondence, on 15 June 1942 Reynolds submitted to the Medical Department a specially prepared monograph on the subject, Medical Problems of Mountain Troops.³¹ Included in this careful scientific study was a detailed discussion of the problems of ski evacuation, descriptions of military practices in various parts of the world, and photographs of a wide variety of French, German, and Swiss ski litters. Such material was of great value in helping to focus and direct the research efforts that were to follow.

Meanwhile, a current experimental phase of Development Project, F-7, "Litter, Folding", was discovered to have a special relevance to the ski litter project now being established. Two models of a Swiss military litter, which the manufacturers claimed could be used in snow and ice conditions without resorting to skis, were being subjected to extensive field tests by the Equipment Laboratory.³² Test results, however, as we have seen in the preceding chapter, were disappointing. The Koller litters, deck-chair in shape, were not only unadaptable to the fittings in ambulances and planes, with components which were not interchangeable with standard litter parts, but they were too intricate in design and too fragile, despite their heavy weight, to be serviceable for field use.³³ This opinion was confirmed by British authorities who had already tested the Swiss litters extensively in rugged, mountainous country.³⁴ It may be observed parenthetically that, in the Polar Bear Exercise staged in Canada during the winter of 1944, Medical Department appraisal of the litter was once more sustained. The reporting board, composed of both Canadian and American officers, found the litter to be "too heavy to be used where powered transport is lacking."³⁵

The above information played an important part in the evolution of a final research plan for the new ski litter project. It will be recalled that the idea of an all-ski improvisation had been applied in the case of the Emergency Ski-Sled, mentioned earlier in this chapter.³⁶ The disadvantages of that method had been such that further experimentation along the same lines was not anticipated. The

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Koller litter, although tested under Development Project, F-7, afforded an equally useful illustration of the limitations of the all-litter type of winter evacuation aid. Thus, the alternatives of dispensing with the litter by using additional skis, or of dispensing with skis by adopting a special, multi-purpose litter, had been examined and discarded at a relatively early date.

This narrowing of research possibilities was clearly reflected in the re-formulation of project objectives and military characteristics submitted by the Equipment Laboratory 8 March 1943. The proposed item was to be "an adaptation or conversion of the standard litter and the standard ski by means of an attachment."³⁷ In other words, from this time forward research activity was to be concentrated solely on a search for a suitable attachment or clamp to fulfill the above purpose. Within the newly restricted sphere of investigation, however, there were still, theoretically at least, two possibilities. Skis could be specially prepared with built-in clamps, as in the 1935 Air Corps assembly, or detachable clamps could be devised. As we shall see presently, however, Medical Department preference was, from the outset, heavily weighted in favor of the latter alternative.

With project objectives now clearly defined, the Equipment Laboratory took immediate steps to obtain practical advice from as many key military and industrial sources as possible. Army War College was contacted for suggestions,³⁸ as was the Mountain Training Center at Camp Hale, Colorado,³⁹ and a winter training unit stationed at Camp McCoy, Wisconsin.⁴⁰ In addition, a number of commercial firms were canvassed for their ideas on the subject.⁴¹ Finally, in order that preliminary laboratory experimentation could be begun without delay, the Equipment Laboratory obtained from the Office of the Quartermaster General copies of all ski drawings and specifications then available.⁴² Shortly thereafter, requisitions were forwarded to The Surgeon General's Office for one set of laminated skis, one set of solid hickory skis, four ski adapters, and four contraction bands.⁴³ With the receipt of this equipment on 26 April 1943, the development phase of Project F-28 was ready to begin.

III. Development Phase.

A. Unsolicited Models.

While actual development work, conducted directly by the Laboratory or under contract with commercial firms, was not initiated until the summer of 1943, during the earlier part of that year several unsolicited ski litter designs were

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received by The Surgeon General's Office. It is at this point that we find the first evidence of a crystallizing of Medical Department attitude in favor of the detachable, as against the built-in, type of ski clamp. Fortunately, the decision was reached soon enough to enable research and development personnel to begin work with a highly specific objective before them.

1. The Lippman Improvisation.

The 1935 Arctic Rescue Unit had consisted of a set of specially prepared skis with permanent attachments which fastened onto the stirrups of a standard Medical Department litter. On 9 February 1943 a new design, representing a further extension of this "permanent attachment" principle, was submitted to The Surgeon General's Office by Lieutenant Richard W. Lippman, Medical Corps, an assistant battalion surgeon serving overseas.

1. Conditions in this region required improvisation of a method for transporting litter-borne casualties over deep ice and snow.
2. A litter was mounted on skis by the following simple method: 1 $\frac{1}{4}$ inch hole was drilled in the center of each stirrup, and matching holes bored in a pair of 7 $\frac{1}{2}$ ft. skis. The litter was bolted in place on the skis, and the bolt heads were set in the grooves, so that there would be little interference with the running surface. No materials were necessary beyond litter, skis, four bolts and nuts, drill, and some lengths of $\frac{1}{2}$ inch rope.
3. It was found that a litter so mounted proved very satisfactory in transporting actual injuries to dispensary from skiing grounds. It was easily handled by two litter bearers, by means of ropes attached fore and aft. If rocky or bare ground is encountered, the skis do not interfere with carriage of the litter in the conventional manner. The mount is easily and quickly assembled and disassembled, and the necessary holes do not impair the normal function of either litter or skis.44

The above suggestion was duly forwarded to the Director of the Medical Department Equipment Laboratory who replied, on 12 March 1943, with the following evaluation:

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This method works all right but requires the preparation of ski and litter and they have to be carried together. The litter and ski in this case become a sleigh and the patient would have to be transferred to another litter. The holes weaken the skis. It is believed that a form of clamp that can be removed from the litter and ski will be more practicable.⁴⁵

It is clear from the above reply that, wholly apart from the specific objections mentioned in connection with the Lippman model, the Equipment Laboratory had already developed a decided preference for the detachable type of ski clamp as against the permanent or built-in type. However, not only the Lippman suggestion, but two other alternative designs in the same general category were to be at least cursorily examined before this particular construction principle was definitely and finally discarded.

2. The American Pressboard "Stretcher-Kot".

This unique item, designed and manufactured by American Pressboard Company, Incorporated, New York City, was first called to the attention of Medical Department officials in April, 1943.⁴⁶ The "Stretcher-Kot", it was claimed, combined the light weight and adaptability of a regulation ambulance stretcher with the added comfort and greater daily usability of a sleeping cot. Equipped with a dismountable ski adjustment (see Fig. 15) and with canvas straps to hold the wounded safely in place during transportation, the model was described by the manufacturer as an ideal instrument for removing casualties from front-line battlefields.⁴⁷

After several weeks of correspondence, on 5 May 1943 The Surgeon General's Office authorized American Pressboard Company to ship a sample stretcher cot with ski attachment to the Equipment Laboratory at Carlisle for field test.⁴⁸ It was agreed that shipping costs would be met by the manufacturer and that the Government would not be liable for any damage to the item incurred as a result of testing procedures.⁴⁹ Receipt of the experimental ski litter was acknowledged by the Equipment Laboratory on 18 May 1943,⁵⁰ and two weeks later a formal report of test results was forwarded to The Surgeon General's Office.

The American Pressboard model consisted of an oval-shaped frame of seasoned bend wood, approximately 78 inches long by 25 inches in width, to which was bolted four 8-inch "U"-shaped wooden legs. To this frame there was attached by rope lacing a sheet of medium heavy duck. The

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stretcher was fastened to a pair of regulation sized skis by means of winged bolts, attached to wooden blocks that were bolted on the skis to form a ski stretcher. The bolt arrangement made it possible to attach or detach the skis as the occasion required.⁵¹

In a formal report to The Surgeon General's Office, dated 31 May 1943, the Equipment Laboratory stated that the stretcher cot had been examined and tested, enumerated certain advantages and disadvantages of the item, and concluded by recommending that the American Pressboard model be rejected. In view of the nature of the disadvantages which were listed, it was evident that elaborate field testing had been unnecessary.

Advantages:

- (1) The subject item uses practically no critical materials. It is light in weight and quite sturdy in construction.
- (2) Cots when removed from skis will quite readily support the average litter load. The canvas top is replaceable when soiled or worn out.

Disadvantages:

- (1) Subject item stretcher cot is a special item of equipment not interchangeable with standard litters and will require transfer of patients to the standard litter to transport in present field ambulance.
- (2) The present litter bar and other accessories for transporting cases will not fit subject stretcher and its use will require additional new type accessories.
- (3) Method of attaching subject item to ski requires a specially prepared ski.

Recommendations: The subject stretcher cot with ski attachment has no advantage over the standard litter with ski clamps and would be an additional item of equipment. Its adoption as standard item of Medical Department equipment is not recommended.⁵²

On 3 June 1943, the above findings were reported to the manufacturer by The Surgeon General's Office,⁵³ and on 14 June 1943 the company's experimental model was returned.⁵⁴

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3. The Davisson Ski Ambulance.

On 3 September 1943, the National Inventors Council of the Commerce Department submitted to The Surgeon General's Office for its consideration and comment a design for a "ski ambulance", prepared by one Henry L. Davisson.⁵⁵ The suggested assembly consisted of four specially prepared skis which were placed parallel to one another and an equal distance apart so that total width, measuring from the outer edges of the two outside skis, approximated the width of a regulation litter. Two crosspieces were fastened laterally to the skis near their ends, giving the unit a toboggan-like appearance. A heavy canvas covering was fitted against this wooden frame and secured to the skis by a series of snap fasteners.⁵⁶ Like the Emergency Ski Sled, mentioned earlier in this section, the Medical Department litter was not used in the assembly.

The above design was forwarded to the Equipment Laboratory on 7 September 1943 for evaluation,⁵⁷ and four days later the following comments were submitted to The Surgeon General's Office by the Laboratory director.

1. The attached NIC file on Henry L. Davisson patent for ski ambulance has been examined with reference to our Project F-28, Ski Clamp.. The following comments are submitted:

- a. The subject invention would require the Medical Soldier to be equipped with four special skis, due to the invention not being applicable to the standard ski without prepared alteration.
- b. The patient would be lying on a piece of canvas right down on the skis. Additional construction would be necessary to support a litter or to raise and hold the canvas up from the hard ski.
- c. Sharp rocks and snags are very apt to extend up between the skis and gouge the patient.

2. Because of the above conditions it is believed that a better ski clamp can be developed using the patient's skis and the ordinary litter and no special skis will be required.⁵⁸

This was the last of the unsolicited models. As in the past, research suggestions submitted independently, without prior consultation as to Medical Department needs and without

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complete information as to the latest developments in the field in question, had contributed little toward a solution of the immediate problem at hand. However, at least one point was now clear. The Equipment Laboratory intended henceforth to focus its entire attention on the development of a detachable ski clamp. That specific objective had been affirmed in each of the Laboratory reports cited in the foregoing pages. With possible research alternatives thus reduced to a single well-formed plan, optimum conditions had been created for the rapid development of a suitable item and, consequently, for an early termination of the project. It was little wonder, therefore, that The Surgeon General's Office now established, as an estimated completion date for Development Project, F-28, the deadline of 1 September 1943.⁵⁹

B. The Lightweight Ski Clamp.

By mid-March, 1943, it will be recalled, the Equipment Laboratory at Carlisle, Pennsylvania, had been authorized by The Surgeon General's Office to begin development work immediately, without waiting for completion of all the remaining formalities involved in securing final Army Service Forces approval of the project.⁶⁰ Accordingly, during the remainder of March, and throughout the whole of April and May, the Laboratory was busy designing and constructing various experimental models of ski litter attachments.⁶¹ By June, 1943, the variety of designs had been reduced to three and a number of hand-made models of each type had been constructed in the Laboratory's workshop.⁶²

In answer to a request from one of the officers stationed at the Mountain Training Center, Camp Hale, Colorado,⁶³ the Laboratory arranged to send one of its sets of experimental ski clamps for examination and brief field trial. It was explained that the samples were being sent mainly to show how the clamp worked. Due to a lack of more suitable material, the attachments had been made of galvanized metal and, consequently, were considerably less rigid than would be the case with future factory models.⁶⁴ The reply subsequently received from Camp Hale, to the effect that preliminary field trials indicated that a somewhat stronger clamp would be necessary, was not, therefore, surprising.⁶⁵ The more significant fact was that no adverse comment had been made as to the item's basic design.

Meanwhile, contract negotiations had been initiated by the Laboratory with the Jerald Sulky Company of Waterloo, Iowa, for the production of a small number of the new ski clamps, using a light gauge carbon steel.⁶⁶ Negotiations were proceeding satisfactorily when it was suddenly learned that, even for this small experimental order, competitive

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bids would be required by the Purchasing Division of The Surgeon General's Office.⁶⁷ Additional commercial firms were thereupon circularized and, after considerable delay, a purchase order was finally placed with the Reading Sheet Metal Products Company, Reading, Pennsylvania. Three different types of litter attachments were ordered, and it was anticipated that delivery would be made by the latter part of August or the early part of September, 1943.⁶⁸ In view of these unexpected developments, the estimated completion date for Project F-28 was extended from 1 September 1943 to 1 January 1944.⁶⁹

About the middle of September, 1943, three sets of ski litter attachments were received from the Reading Sheet Metal Products Company, and were forwarded to the Commanding General, Mountain Training Center, Camp Hale, Colorado, for extensive field testing.⁷⁰ Three weeks later, the Laboratory was notified by The Surgeon General's Office that a cold weather maneuver, to be held from 1 December 1943 to 15 January 1944, had been scheduled for the Alaskan Defense Command. Some three hundred men were to make a cross-country move over various terrain in temperatures down to minus forty degrees Fahrenheit. On the maneuver, all types of medical field equipment were to be given a thorough evaluation as to cold weather efficiency and suitability. It was therefore suggested by The Surgeon General's Office that this would be an excellent opportunity for the Laboratory to test any of its winter equipment which had been recently developed or was now nearing completion.⁷¹

Having no extra ski clamps on hand, and judging apparently that too much time would elapse before receipt of the additional sets which had been ordered, the Laboratory stated that it did not anticipate sending any equipment for the test.⁷² However, on 22 November 1943, a shipment of forty-eight sets of the ski litter attachments was received from the Reading Sheet Metal Products Company,⁷³ so, on the following day, three sets of these clamps were hastily forwarded to the Alaskan Defense Command with this notation:

Remarks and recommendations from the Equipment Board, Alaskan Defense Command, are requested in regard to the feasibility of using the ski clamp for the conversion of the standard litter and skis to a ski litter. In addition, any suggestions in regard to the improvement of the ski clamp will be appreciatively received by this office.⁷⁴

The Equipment Laboratory, it should be noted, was still contemplating that its project would be completed by 1 January 1944.⁷⁵ A favorable test report was expected momentarily from Camp Hale, to which sample sets of the new ski attachment

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had been sent in mid-September, 1943. Upon receipt of this report, standardization proceedings could be initiated while awaiting further confirmation from the Alaskan Defense Command. Yet January arrived and still there was no word from this quarter. Impatient at the continued delay, and favored by good winter conditions in the Appalachian Mountains surrounding Carlisle, Pennsylvania, Laboratory personnel decided to perform their own field tests of the new ski clamp without waiting any longer for replies from Colorado and Alaska.

No detailed reports of these Laboratory-conducted field tests were submitted to The Surgeon General's Office. It was simply stated that all three types of ski litter attachments were locally tested, and that one type was found to be suitable for the purpose intended, with the exception that the material of which it was constructed was not sufficiently heavy nor of high enough carbon content to withstand the mechanical stress to which it would be subjected.⁷⁶ Accordingly, the beginning of February having arrived, with still no report received from either Camp Hale or the Alaskan Defense Command, the Laboratory immediately set about ordering clamps of the selected design, to be constructed of a heavier gauge and higher carbon content steel.⁷⁷

It was indeed fortunate that the Equipment Laboratory on its own initiative thus undertook to speed up the project as much as possible. So far as can be discovered no test report on the lightweight ski clamp was ever submitted either to the Laboratory or to The Surgeon General's Office by the Mountain Training Center at Camp Hale.⁷⁸ As for the Experimental Board of the Alaskan Defense Command, to which three experimental ski clamp sets had been shipped on 19 November 1943, a formal report of test findings was finally forwarded to the Laboratory on 16 May 1944. Since the clamps were apparently received too late to be used on the December and January maneuvers, tests had been conducted instead at McKinley Park during February and March, 1944. These were described as follows:

- a. Tests were conducted in snow conditions with various hard and soft surfaces, depths ranging from one (1) to five (5) feet, over broken and unbroken trails, and terrain conditions of open level or rough unbroken topography thick with brush and undergrowth.
- b. Patient evacuations were made from front line areas rearward to simulated battalion aid stations and collecting stations, timing actual operations, fatigue of personnel, comfort of patient, and action of ski-litter in varying situations.⁷⁹

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The specific results of these various tests were reported as follows:

- a. When assembled, this combination formed a very light and practicable means of patient evacuation for open, relatively smooth, hard surfaces. Under such conditions a two hundred (200) pound casualty was easily moved by one person.
- b. Traversing soft snow surfaces, areas of rough timber, burnt-over territory, or brushy terrain, however, evacuation was found difficult to the point of having been nearly impossible. Insufficient ski flotation permitted the litter bed to "belly up" on obstacles and scoop snow like a plow, under some conditions losing all sled action.
- c. Extending free ends of litter poles gathered small brush and trees between them and caused continuous fouling.
- d. Stumps and brush obstructions concealed by snow collided with the spreader bar, abruptly jarring the patient and sometimes jerking the aid man in harness off his feet.
- e. The combination followed snowshoe trails very poorly because of its tendency to "wander" from one side to the other, making pulling quite difficult.⁸⁰

Summarizing the above test findings, the Experimental Board concluded that: (1) The ski attachments were satisfactory only on hard surfaced, open, level snow; (2) They were not satisfactory for arctic or sub-arctic medical operations. It was recommended that, instead of continuing the attempt to accommodate the regulation litter to skis, a Stokes type of litter constructed of plywood be developed for use with toboggan type sleds.⁸¹ In short, what was here being questioned was not merely the suitability of the design and construction of the specific ski clamp which had been submitted for test, but the basic practicability of any type of ski litter adaptation.

The Board's contention that the general usefulness of a ski litter was too slight to warrant further consideration was not sustained by the Medical Department. The evidence to the contrary was, in fact, considerable. In the first place, communications received from overseas units indicated not only that there was a definite need for a ski litter but also that

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even crude improvisations, involving the use of prepared skis, were being utilized successfully over mountainous as well as level terrain.⁸² In the second place, the existence of a definite military requirement for a ski litter had been officially confirmed by Army Ground Forces which had likewise approved the initiation of a formal research project to develop such an item. Finally, the development of a toboggan litter, as suggested by the Experimental Board, was already in progress under a separate research project.⁸³ Inasmuch as the toboggan and ski litters were being designed for different but equally essential purposes, there appeared to be no good reason why either item should supplant the other.

Significantly, no further ski litter models were sent to the Alaskan Defense Command by the Equipment Laboratory at Carlisle. The Experimental Board had taken six months to submit a report of its findings, and, while the test results themselves were of value, no suggestions for improvement of the clamp had been offered although this information had been specifically requested. In brief, the report had done little to hasten a practical solution of the research problem facing the Medical Department. As for the Mountain Training Center at Camp Hale, as mentioned earlier no report at all appears to have been received. The actual decision, therefore, to abandon further work on the lightweight ski attachment and to shift attention to a more rugged type of construction had to be made exclusively by the Laboratory at Carlisle, on the basis of such field tests as it had been able to perform locally.

C. The Heavy Gauge Ski Clamp.

In January 1944, four months before the Alaskan Defense Command report had been received, the Equipment Laboratory began negotiations for the commercial production of a limited number of ski clamps of a heavier construction than those which it had just tested and found too fragile for field use. The competitive bidding requirements which had been encountered six months earlier had apparently now been rescinded, for the Laboratory was able this time to confine its negotiations to a single company. The advantages of this latter arrangement were considerable. Instead of having to produce in final form a complete set of drawings and specifications, to be turned over routinely by purchasing authorities to the lowest responsible bidder, the Laboratory was now able to select an interested manufacturer and, through a free and extensive exchange of ideas, work out improvements in its original blueprints before actual factory production was scheduled to begin.

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It was in precisely this fashion that several useful changes in specifications were evolved in the present instance. On 17 January 1944, the Equipment Laboratory wrote to the Jerald Sulky Company, Waterloo, Iowa, requesting quotations on twelve ski clamps to be made of 11 gauge 1045 S.A.E. steel.⁸⁴ In its reply, the Jerald Sulky Company pointed out that it would be impossible to obtain the type of steel specified unless a special mill run were obtained, which would be very difficult in view of the wartime shortage of the metal. Moreover, the company stated, it was the opinion of a number of expert metallurgists who had been consulted that no practical method had yet been found for welding steel higher than 1030 grade. It was therefore proposed that 14 gauge, 1020 steel be used in the construction of the clamp components, the parts then to be hardened with cyanide. The additional cost of this method, it was explained, would amount to approximately 25¢ per item, bringing total unit cost to \$4.10 per clamp.⁸⁵

This alternate method of manufacture was approved by the Laboratory,⁸⁶ whereupon the company made one further suggestion for improvement of specifications. It was stated that a much neater appearing ski attachment could be produced if, instead of using nuts with separate welded wings, one-piece wing screws were substituted. Inasmuch as the Laboratory already had the necessary number of these wing screws on hand, the company suggested that they be forwarded, their cost to be deducted from the final bill.⁸⁷ This proposal was likewise accepted, the Jerald Sulky Company was granted an AA-1 priority, and within two weeks 12 fabricated heavy gauge clamps were delivered to the Laboratory.⁸⁸ The new attachments had been manufactured at a total cost of less than \$50. Evidently in this instance competitive bidding had not been necessary to bring prices down to a reasonable level.

On 24 February 1944, one set of the improved ski clamps, which were similar in design to earlier models but were now constructed of stronger material, were shipped to the Mountain and Winter Warfare Board, Camp Hale, Colorado, for field test.⁸⁹ This time the Laboratory was determined to make its own investigation immediately without waiting for reports from the field. Accordingly, before the close of the month, the new attachments were locally tested and this time the results appeared wholly satisfactory.⁹⁰ No formal report, however, was submitted to The Surgeon General's Office giving detailed test findings. In view of subsequent events, it will be observed that the absence of a complete statistical record of these local field trials was a decided handicap to the Medical Department.

On 5 May 1944, with no information as yet forthcoming from the Mountain and Winter Warfare Board at Camp Hale,

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the Equipment Laboratory forwarded to The Surgeon General's Office a complete set of tentative specifications, drawings, and photographs.⁹¹ As this was customarily the final step in development activity, it is evident that the Laboratory now considered the project completed, confident that its own test findings would be confirmed by the Camp Hale board. After some delay, on 13 June 1944 this data was sent by The Surgeon General's Office to the Research and Development Division, Army Ground Forces, with the request that the former office be advised if standardization of the subject item was recommended.⁹² In view of the favorable reaction which was expected, the reply which was received from Army Ground Forces several weeks later must have come as a distinct shock.

1. The litter clamp described is similar to the standard adapter, ski, recently tested by the Mountain Board, and found to be unsatisfactory due to instability of the litter when so supported and tendency of the ski runner to collapse in turns. This report of test of winter evacuation equipment is now being studied in this headquarters.
2. It is recommended that no further consideration be given the subject litter ski-clamp, Type C.⁹³

The above statement was subsequently approved by the Research and Development Division, Army Service Forces. On 6 July 1944, that office endorsed the Ground Force recommendation and directed that further work on the Carlisle model be discontinued.⁹⁴ Upon receipt of these two communications, the Chief of the Research Coordination Branch, Surgeon General's Office, immediately addressed a memorandum to the Chief of the Development Branch, directing the latter to discuss with Army Ground Forces as soon as possible the question of improvement of the Type C ski clamp and of continuation of the research project.⁹⁵

The test report of the Mountain and Winter Warfare Board, which had been forwarded to Army Ground Forces on 17 June 1944, was a lengthy document covering test findings on a wide variety of winter evacuation equipment. Intensive field tests had been conducted at the Mountain Training Center from 8 March 1944 to 2 June 1944. Insofar as the ski litter was concerned, a special winter evacuation course, one mile in length, had been established for the testing of these adaptations in over-the-snow movement. This course, according to the report, included the common types of terrain and conditions usually encountered during evacuation by sled or ski. It was stated, however, that due to the lateness of the season, only limited conditions of powder snow were encountered. Instead a heavy spring pack and snow of high water content had

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predominated.⁹⁶

Two types of ski adapters were tested during the above maneuver: the Carlisle Model (Type C), developed by the Equipment Laboratory; and the Hale Model (Type D), developed by the Mountain and Winter Warfare Board. While both items operated on an essentially similar compression principle, there were certain important differences in design and construction. The Carlisle Model consisted of a steel clamp with grooves on each end, one end fastening around the edges of the ski runner, the other end closing around the litter stirrup. The clamp was fashioned with a single ring-nut tightening adjustment.⁹⁷ The Hale Model clamp was also of steel construction, was grooved at both ends, but was longer than the Carlisle Model so that the upper end fastened onto the base of the stirrup block instead of the lower end of the stirrup itself. Because of this additional length, two ring nuts were required instead of one for the tightening mechanism.⁹⁸ For both models, four clamps constituted a complete set.

While detailed test findings were not quoted in the Board report, photographs were appended showing the failure of the Carlisle adapters in two general instances. Used with standard skis and a folding aluminum litter, stirrups and runner had collapsed due to lack of support provided by the clamps. Used with standard skis and the mountain litter, Carlisle Model, one ski runner had collapsed due to insecure grip provided by the Carlisle adapters. The conclusions of the Mountain and Winter Warfare Board, on the basis of all field tests conducted, were as follows:

The Carlisle Ski Adapters provided for use with the standard canvas bed litter were . . . unsatisfactory in that they would fit only a limited number of skis, and in their lack of provision of a much needed support to the stirrups of the Litter, Folding, Aluminum. The Adapters, All-Purpose, Camp Hale Model, on the other hand, were found to accomplish the tri-purpose function of fitting onto any size of ski, providing an efficient means of attaching saplings to the stirrups of the litter, and of providing support to the stirrup mechanism. Without these adapters, or an adapter which accomplishes the same results, efficient evacuation in the mountains when using the Litter, Folding, Aluminum is difficult, if not impossible.⁹⁹

The Board thereupon recommended that the Camp Hale, or Type D, ski adapter be adopted as a standard item, and that the

Carlisle adapter, Type C, be rejected for over-the-snow evacuation.¹

It will be seen from the foregoing Board report that, explicitly or by implication, three major criticisms had been made of the Equipment Laboratory's ski litter adaptation. In the first place it had been charged that the Carlisle adapter had failed to furnish a stable conversion for the mountain litter. It could be argued, of course, that the mountain litter was not yet a standard item and that the Laboratory was not obliged to accommodate its design to purely developmental litters. However, the Laboratory was aware of the existence of such a litter, having developed it in its own workshop, and in the event that the mountain litter was accepted for standardization the problem of adapting the new item for use with the standard ski would have immediately presented itself. To have anticipated this possibility would seem to have been a reasonable precaution against costly alterations at some future date.

In the second place the Board had charged that the Carlisle adapter had not been designed to fit all types of Quartermaster skis. We have seen how the Laboratory, at the start of the ski litter project, had carefully studied Quartermaster ski specifications and had obtained actual samples of each type then in existence in order to insure complete adaptability of the proposed ski clamp. Nevertheless, as we shall see presently, the Board's finding in this regard was valid. The Laboratory had not continued to keep itself informed as to changes and additions in the Quartermaster supply listings. New skis had been standardized, apparently without the Equipment Laboratory's knowledge, to which the Carlisle clamps were clearly not adaptable.

In the third place it was charged that the Carlisle adapters had not been designed to fit the folding aluminum. This finding, as we shall see, was also valid. It will be recalled from an earlier chapter that, with the growing scarcity of aluminum, a double-folding laminated wood litter had been developed by the Laboratory as a procurement substitute.² It will also be recalled that the Laboratory was strongly opposed to the continued distribution of those folding aluminum litters still in stock which were designed with folding, instead of stationary, stirrups.³ Neither of these facts, however, eliminated the necessity of making the Carlisle clamps adaptable to all litters which were still being used in the field, whatever their individual merits. Neither the stationary or folding stirrup type of folding aluminum litter had been declared obsolete and, until such a reclassification had been officially ordered, there was always the possibility that a medical corpsman would be faced with the practical necessity of converting such a litter to ski use.

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The present clamp would be of little service in this situation.

In its first indorsement to the Camp Hale communication inclosing the above test report, Army War College, speaking for Army Ground Forces, entered the following official recommendations:

It is recommended that the present Adapter, Ski be reclassified limited standard, and the Adapter, All-Purpose, be adopted as a standard article under the nomenclature "Adapter, Ski, M-1944, Set of 4". There is no objection on the part of this headquarters if the above changes can be accomplished by change of specifications only. It is recommended that the following military characteristics be adopted:

- (1) Shall consist of 4 clamps suitable for attachment to all standard skis and litters for improvising an over-snow, hand-drawn vehicle.
- (2) Shall provide a secure connection between the litter and the skis and shall not collapse in normal use on slopes and turns.
- (3) Shall be as light in weight as possible consistent with the durability required under subdivision (2).⁴

The indorsement concluded with the recommendation that a basis of issue for the new item be set up under the provisions of Table Allowance 20-2, and that distribution be specified for Alpine and Cold Zone units at the rate of one set of four clamps for every four litters (other than mountain). It was added that this proposed basis of issue should be revised and broadened if new Tables of Organization and Equipment were adopted for mountain and winter troops.⁵

It will be noted that Army War College apparently had the impression that the Carlisle clamp had already been adopted as a standard Medical Department item. This, of course, was not true. The Carlisle and Hale models were both developmental items only, and no catalog changes would be necessary in the event the latter was selected. Aside from this minor error, however, the above recommendations followed closely the test findings of the Mountain and Winter Warfare Board. Moreover, on 22 August 1944, the Research and Development Division of Army Service Forces concurred in the Army War College recommendations and directed that the Hale, or Type D, clamp be processed through the Medical Department Technical Committee at the earliest practicable date.⁶

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While the negative findings of the Mountain and Winter Warfare Board with respect to the Carlisle adapter had been largely valid, it was soon discovered that the positive recommendations regarding the Hale adapter had been somewhat hasty. During September, 1944, the Equipment Laboratory received several samples of the Type D clamp and, upon inspection, found that this ski clamp had been designed to fit only one litter, Item No. 9938000, Litter, Folding, Aluminum, which was provided with folding stirrups.

Inasmuch as the Carlisle Model already fit all but one type of Medical Department litter, while the Hale Model had been designed to fit only one of six standard litter types, the superiority of the former now seemed quite evident. In its reply, however, the Equipment Laboratory carried the matter one step further.

It is the opinion of this office that Type C, ski clamp is the preferred type ski clamp inasmuch as it will operate with all Medical Department litters with exception of Item No. 9938000, Litter, Folding, Aluminum.

It is further the opinion of this office that the folding stirrups on Item No. 9938000 should be replaced by a non-folding type stirrup, if its use is contemplated as a ski litter.⁷

The Equipment Laboratory had campaigned long and hard against the adoption of the folding stirrup type of aluminum litter,⁸ and it is quite understandable that it did not wish to overlook this opportunity to re-emphasize the defects of that particular litter design. However, as has been pointed out, so long as folding stirrup litters were in use in the field, complete adaptability of the new ski clamp would not be attained until the item had been redesigned to fit this litter also. In short, preference for the Carlisle adapter over the Hale adapter did not preclude some modification of the former item.

On 16 September 1944, The Surgeon General's Office, in its reply to Army Ground Forces, began by considering the main point at issue--the Carlisle versus the Hale adapter. Unfortunately, not all of the evidence here introduced to back the claim of the Carlisle item was of a noncontroversial sort.

It is noted that the ski litter adapter was tested on a nonstandard folding aluminum pole litter. This ski litter adapter when used on a standard litter was found satisfactory by the Alaskan Board in their winter report.⁹

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The above statements were open to some question. In the first place, the folding aluminum litter was not a nonstandard item, but was still listed as standard in the Medical Supply Catalog.¹⁰ While it was true that official specifications called for non-folding feet, it will be recalled that the folding feet feature had been specially prescribed for all litters procured for Army Air Forces. As for the reaction of the Alaskan Board, if reference to its May 16th report was intended, it would be difficult to construe those findings as being more positive than negative.¹¹

In any event, after presenting the above viewpoint The Surgeon General's Office went on to make the constructive suggestion that, since no actual requirements existed for the item, a further test be conducted without delay at a place suitable to Headquarters, Army Ground Forces. At this time all available models of ski litter adapters, as well as other winter evacuation equipment items, could be tested comparatively and the results carefully examined. It was estimated that such test could be concluded in approximately two or three weeks, and that the results would assure that the most satisfactory item available for the purpose intended would be submitted for standardization.¹²

In answer to the above comments and suggestions, Army Ground Forces replied as follows:

1. This headquarters does not concur with the conclusions contained in paragraph 5 of 3rd Indorsement. A present requirement exists for the subject equipment and additional requirements are anticipated.
2. In reference to recommendation in paragraph 5 of 3rd Indorsement that further comparative test be conducted without delay, this headquarters would have no objection to further tests in advance of standardization but no units or personnel are available to carry out such expedited tests
3. Because of replacement of Litter, Folding, Aluminum by other litters it is recommended that development of the Adapter, Ski be continued to produce an adapter suitable for use with the Litter, Straight, Steel, or a new folding aluminum litter.¹³

According to the nomenclature used in the previous Ground Force communication, the term, "Adapter, Ski", referred to the Carlisle clamp, while the term "Adapter, All-Purpose", referred to the Hale model. Therefore, it can be seen that

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in the above indorsement Army Ground Forces was indicating its willingness to accept the Carlisle design, provided that it was altered to fit all existing Medical Department litters. The Hale model was no longer being considered as a practicable alternative.

The above Army Ground Force recommendations were soon concurred in by Headquarters, Army Service Forces,¹⁴ and the Equipment Laboratory was charged with the task of suitably modifying its original drawings of the heavy gauge clamp. By the end of October, 1944, the Laboratory submitted the following report of its progress.

- a. In order that the ski clamp could accommodate the stirrup of the aluminum folding litter, it was redesigned and revised drawings covering the changes were forwarded to The Surgeon General on 17 October 1944.
- b. Inasmuch as the type ski now provided by the Quartermaster Corps is of a different type than that which was used in the development of the ski litter clamp, further changes in its design may have to be made. With this in mind, standard type skis and cross-country skis of the latest type will be made available to this office.¹⁵

On 27 November 1944, the Laboratory received from the Boston Quartermaster Depot two of the new type Quartermaster skis; one, standard type; the other, cross-country type.¹⁶ Redesign of the ski clamp was initiated immediately to accommodate the adapter to both types of skis (see Fig. 16) and, on 4 December 1944, the final modified drawings were forwarded to The Surgeon General's Office.¹⁷ All that now remained to be accomplished was formal processing of the item for standardization. As we shall see, even this final procedural phase was not without its complications. From now on, however, the delays were brief in comparison with what had gone before.

IV. Standardization Phase.

Immediately upon receipt of the Army Ground Force communication, stating that a suitably modified Carlisle, or Type C, ski clamp would be acceptable to that office, the Technical Division of The Surgeon General's Office set about preparing final standardization data. On 5 October 1944, standardization forms, photographs, drawings, tentative specifications, and Army Ground Force recommendations regarding basis of issue and military characteristics were forwarded to all Technical Division branches for preliminary action.¹⁸ With

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one exception, all necessary standardization information had been collected, revised, and arranged in final form by the Division before 13 October 1944, the date of the next scheduled meeting of the Subcommittee of the Medical Department Technical Committee. Total quantity requirements and replacement rates for the new ski clamp were the only matters on which specific data was still not available.

What was ultimately to develop into a requirements controversy began innocently enough. On 6 October 1944, the Supply Coordination Branch of the Technical Division forwarded to the Requirements Branch of the Supply Service a copy of the proposed basis of issue for the ski adapter, and requested that total requirements and replacement rates be calculated as soon as possible.¹⁹ Supply Service replied that they were unable to compute any requirements at that time due to the pressure of other work having top priority.²⁰ There the matter was allowed to rest, at least for the time being. Since no basic disagreement had as yet come to the surface, it was assumed that the information would be available at a later date. As time went on, however, it became increasingly evident that this problem had its ramifications. It was, in fact, destined to plague both the Medical Department and Army Ground Forces for a period of nearly five months.

On 13 October 1944, the Subcommittee of the Medical Department Technical Committee met to consider standardization of the new ski clamp. Among the actions which were then taken was a revision of military characteristics to include, as an additional paragraph, the following condensation of Army Ground Force proposals:

- e. Shall not collapse in normal use on slopes and turns either due to structural failure or design when properly adjusted.²¹

The Subcommittee also followed closely Ground Force recommendations regarding basis of issue. Army War College, it will be recalled, had proposed that one set of the ski clamps be issued for every four litters (other than mountain) used in Alpine and Cold Zones. This proposal was now adopted with but a single minor change. The Litter, Semi-rigid, as well as the Litter, Mountain, was to be excepted in computing the issue rate.²²

Meeting on 16 October 1944, the Medical Department Technical Committee approved in substance the report of its subcommittee. Only two minor changes were made. Nomenclature of the new item was changed from "Adapter, Ski, Litter," to "Adapter, Litter, Ski," and to the above statement of basis of distribution were prefaced the words, "To be included in T/A 20-2, equipment for training purposes."²³ Since these processing actions had taken place with full Army Ground Force

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approval, registered through its representatives on the aforementioned committees, all standardization data was now forwarded to Headquarters, Army Service Forces, for final official approval.²⁴ On 3 November 1944, Army Service Forces approval was formally granted, and it was requested that changes in the Army Supply Program resulting from this action be processed immediately in accordance with established procedure.²⁵

Thus the issue of requirements and replacement rates was once again forced into the foreground. On 6 November 1944, the Research Coordination Branch of the Technical Division forwarded all pertinent information regarding the newly standardized ski adapters to the Chief of Supply Service, with the request that Army Service Forces be notified at the earliest moment concerning production schedules.²⁶ Approximately two weeks later, Supply Service announced that Item 9901675, Adapter, Litter, Ski, would be available for distribution during the First Quarter of 1945.²⁷ As yet, it will be observed, nothing had been done toward computing the quantity to be manufactured. Under the circumstances the production estimate was somewhat optimistic. Actually it was June, 1945, before the first factory order was finally placed.

The completion of other last-minute details seemed, however, to be progressing satisfactorily. On 4 December 1944, the Equipment Laboratory at Carlisle forwarded to The Surgeon General's Office final drawings and specifications for the ski clamp, incorporating all structural changes that had been made in adapting the item to the folding aluminum litter and the new Quartermaster skis.²⁸ Except for requirements data, it now appeared that the item was virtually ready to be processed for procurement. At this point, however, it was suddenly discovered that the Catalog Branch of Supply Service, through a misunderstanding as to what was to constitute a "unit" of the item, had set up an incorrect listing of the unit price of the ski attachment. Instead of indicating that the unit price of \$7.50 covered the cost of a complete set of four adapters, the price was shown as applying to only a single adapter.²⁹

Although the Technical Division had carefully included in the nomenclature of the item the sentence: "Four are required per litter when skis are used," it was now found desirable to spell out the unit definition more explicitly. Accordingly, by action of the Subcommittee of the Medical Department Technical Committee on 1 January 1945, nomenclature was once again revised.

Adapter, Litter, Ski, Set of 4: For Fastening Standard Ski to Provide for Transportation of Wounded. 1 set required per litter when skis are used. Unit - Set.³⁰

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At the same Subcommittee meeting one other change was introduced and approved which was somewhat less understandable. In place of the basis of issue previously described, the following new basis of distribution was substituted:

1 Set per 4 litters when authorized by Army commander; outside continental United States when authorized by T.O. commander.³¹

Concurrence with both of the above recommended changes was given by Headquarters, Army Service Forces on 22 January 1945.³²

All loose ends had now been securely tied with one major exception. No determination of the quantity of adapters to be procured was yet forthcoming. On 10 February 1945, Supply Service broke its long silence. It appeared that Supply Service was not without its own grievances. Upon publication of the original basis of issue on 6 November 1944, supply officials had immediately contacted the Ground Surgeon's Office where they were advised that there was but one Mountain Division in training at that time. Requirements, the communication stated, were thereupon computed on that basis.³³ With the adoption, in January, 1945, of a wholly new basis of issue, the problem had now become exceedingly awkward.

The Technical Division was contacted and could give no definite information as to the quantity that would be needed. Major Brookshire was also contacted and in turn contacted Army Ground Forces G-3, G-4, and Requirements, none of whom could make any estimate as to the quantity needed. Major Brookshire suggested a recommended purchase of (500) to supply two divisions with initial issues and replacements.³⁴

The concluding recommendations of Supply Service were as follows:

In view of the fact that it is impossible for Requirements Branch to compute or justify requirements on this basis one of the two following recommendations is suggested.

- a. That the office which initially submitted the item for standardization make a written recommendation of the desired quantity to purchase or,
- b. Withdraw the item entirely.

Formal action by Requirements Branch is being withheld until the above requested information is received.³⁵

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The indecision on the part of Army Ground Forces, as indicated above, was somewhat surprising. When, back in September 1944, The Surgeon General's Office had suggested that since no actual requirement existed for the item, standardization of the ski clamp be deferred until further comparative tests were performed, Army Ground Forces had replied:

This headquarters does not concur with the conclusions contained in paragraph 5 of 3rd Indorsement. A present requirement exists for the subject equipment and additional requirements are anticipated.³⁶

Now the shoe was on the other foot. Although Ground Forces was not denying that a requirement still existed, it was apparently unable to express its needs in definite quantitative terms.

The vigorous approach adopted by Supply Service proved, however, to be effective. On 19 February 1945, the Executive Officer of The Surgeon General's Office addressed a communication to Army Ground Forces, quoting verbatim the recommendations of Supply Service.³⁷ A month later a reply from Army Ground Forces was received, the pertinent sections of which are given below.

2. This headquarters has no information upon which to recommend procurement of the subject item since information is not available as to contemplated deployment of troops requiring this equipment. Inclusion in Tables of Organization and Equipment is not feasible.

3. There is no present requirement for the subject item for training purposes in this country for the next six (6) months. However, this does not at all mean that there may be no overseas requirements now or in the coming winter. Information of this nature can be obtained only from the theaters.

4. In order that more specific data may be available this headquarters will initiate action to notify the theater commanders of the standardization of the subject item with a request to submit tentative requirements. Pending receipt of theater requirements it is recommended that initial procurement be made of one thousand (1,000) sets of the subject item.³⁸

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The Medical Department now had a definite procurement figure to work with, even though it had been arrived at by rather subjective methods. On 28 March 1945, the recommendation of Army Ground Forces that 1,000 sets of the ski adapters be procured was approved by the Director of Plans and Operations, Army Service Forces,³⁹ and, on 30 March 1945, copies of all indorsements were forwarded for procurement action to the Supply Service of The Surgeon General's Office.⁴⁰

V. Conclusion.

A. Procurement History.

The first production order for the new ski adapters was not placed until 27 June 1945. A total of 1050 sets were ordered at that time, at a unit cost of \$7.16, somewhat under the earlier estimates. As of 26 July 1945, no deliveries had as yet been made on this original contract, and no new contracts had been negotiated.⁴¹

B. Recently Submitted Improvisations.

The need for a more effective information service, informing overseas units of the latest developments of the Medical Department Equipment Laboratory, was emphasized by a number of communications which were received by The Surgeon General's Office long after the standardization of the Adapter, Litter, Ski. One of the first was a letter from the Office of the Chief Surgeon, European Theater of Operations. The remarks indicate that even at this high echelon, nothing was known of the recent ski clamp development.

Reports received by this headquarters indicate that many forward medical units are successfully utilizing improvised ski litters in transporting patients. A photographic report on the efficiency of this method of transporting casualties is contained in combat film sequence LIB 2243, which has been forwarded to Army Pictorial Service, your headquarters.

Recommend that development of a standard ski for attachment to litters be considered. It is suggested that a ski be developed with a clamp attachment to be secured to the litter stirrup. The attachments should be movable to accommodate litters with varying interstirrup distances.⁴²

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Of the other communications received after this date, only one will be cited here. This was a letter from the Seattle Port of Embarkation and contained a description of a new type ski litter which had been developed on the Pacific Coast. The case affords not only further evidence of the fact that insufficient publicity had been given to the ski clamp developed by the Equipment Laboratory, but also indicates, on the positive side, that the item just standardized still represented a more practicable design than any of those which had been submitted from outside sources. Pertinent portions of the Seattle letter are given below:

On 6 March 1945 an inspection was made of a type of litter mounted on skis which was designed by Mr. Erickson, Associate in Physical Education at the University of Washington. This litter mounted on skis was designed as a result of Mr. Erickson's participation in numerous expeditions to remove injured persons from the nearby snow-covered Cascade Mountains.⁴³

The new litter was described as follows:

There is a distance of eighteen inches between the litter and the skis. The addition of skis and braces does not greatly increase the weight of the litter. As shown in the photographs, the skis are attached to the litter by oval bands of metal which are secondarily supported by means of cross struts. These struts can be fastened in place by means of wing nuts, and when they are removed, the litter can be folded flat in the usual manner. This litter possesses the advantages of:

- a. The patient is kept about eighteen inches off the surface of the snow.
- b. The litter can be easily handled and controlled by two men on skis.⁴⁴

The above information was duly forwarded to the Equipment Laboratory at Carlisle for recommendations. On 5 April 1945, the Laboratory replied as follows:

1. The inclosed correspondence and photographs have been studied by this office and following comments submitted.
 - a. Apparatus will serve for the purpose of transporting patients over snow.
 - b. It has the advantage over present ski adapters in that patient is higher off the snow.

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- c. It has the disadvantage of size and weight and of fact that ski has to be prepared. Holes have to be made in them and shoe attachments taken off. This precludes use of patient's skis and requires that a pair of prepared skis be carried.
 - d. The added height tends to make the unit more wobbly.
2. In view of par 1 c. above this apparatus is not recommended for Medical Department procurement and use. It is the opinion of this office that our present standard litter ski clamps better serve our purpose.⁴⁵

C. Evaluation of Development Project, F-28, Litter, Ski.

Whatever might be said critically of the development activities which have been described in previous chapters of this study, the net results had been impressive. New straight and folding pole litters had been developed in time to be of material assistance to overseas troops, and these items had stood up well under combat conditions. The contributions of Development Project, F-28, however, were much less tangible. The end product had not reached supply depots until after World War II hostilities had ceased and, consequently, no extended opportunity was available for testing the new ski clamp under actual combat conditions.

In view of the relative simplicity of the clamp which was eventually standardized, it is difficult to realize that three years were required for its development and procurement. While the causes were various and are not easy to assess, an enumeration of some of the major delays encountered during the course of the project may serve as at least a partial explanation.

The immediate responsibility for the length of time taken to complete Development Project, F-28 did not rest solely with the Medical Department and its research facility at Carlisle, Pennsylvania. Other installations, as well as other components of the Army, had also contributed to the total delay that had occurred. Army Ground Forces had taken six months to submit the necessary statement that a military requirement existed for a ski litter attachment. Six months had elapsed before the Alaskan Defense Command had submitted its test findings on the lightweight ski clamp. The Mountain and Winter Warfare Board had taken nearly four months to report the results of its field trials of the heavy gauge clamp.

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Considerable time had, of course, been consumed in carrying out purely Medical Department activities. The Surgeon General's Office had taken five months to fulfill procedural requirements incident to project initiation. Processing the finished item for standardization and procurement had taken another five months. The Equipment Laboratory, by neglecting to design its adapters to fit all types of Quartermaster skis and all types of straight and folding pole litters then in use by the Medical Department, had caused further delays. Project termination had likewise been impeded by Supply Service delays in computing total requirements and replacement rates for the new item.

It is entirely possible, however, that most of the above factors were in reality symptoms rather than basic causes. The ski litter adapter, it should be remembered, was a minor equipment item and, while a potential military requirement existed from the start of the undertaking, this potential demand never became actual and urgent at any time during the course of the war. From its inception, therefore, Development Project, F-28 was a low priority project, and this simple lack of pressure may well have accounted for many, if not most, of the delays just mentioned.

In any event, there were no serious consequences. And, constructively regarded, an end item had been produced and standardized which, from all accounts, was greatly superior not only to all previous standardized attachments but to all later field improvisations as well.

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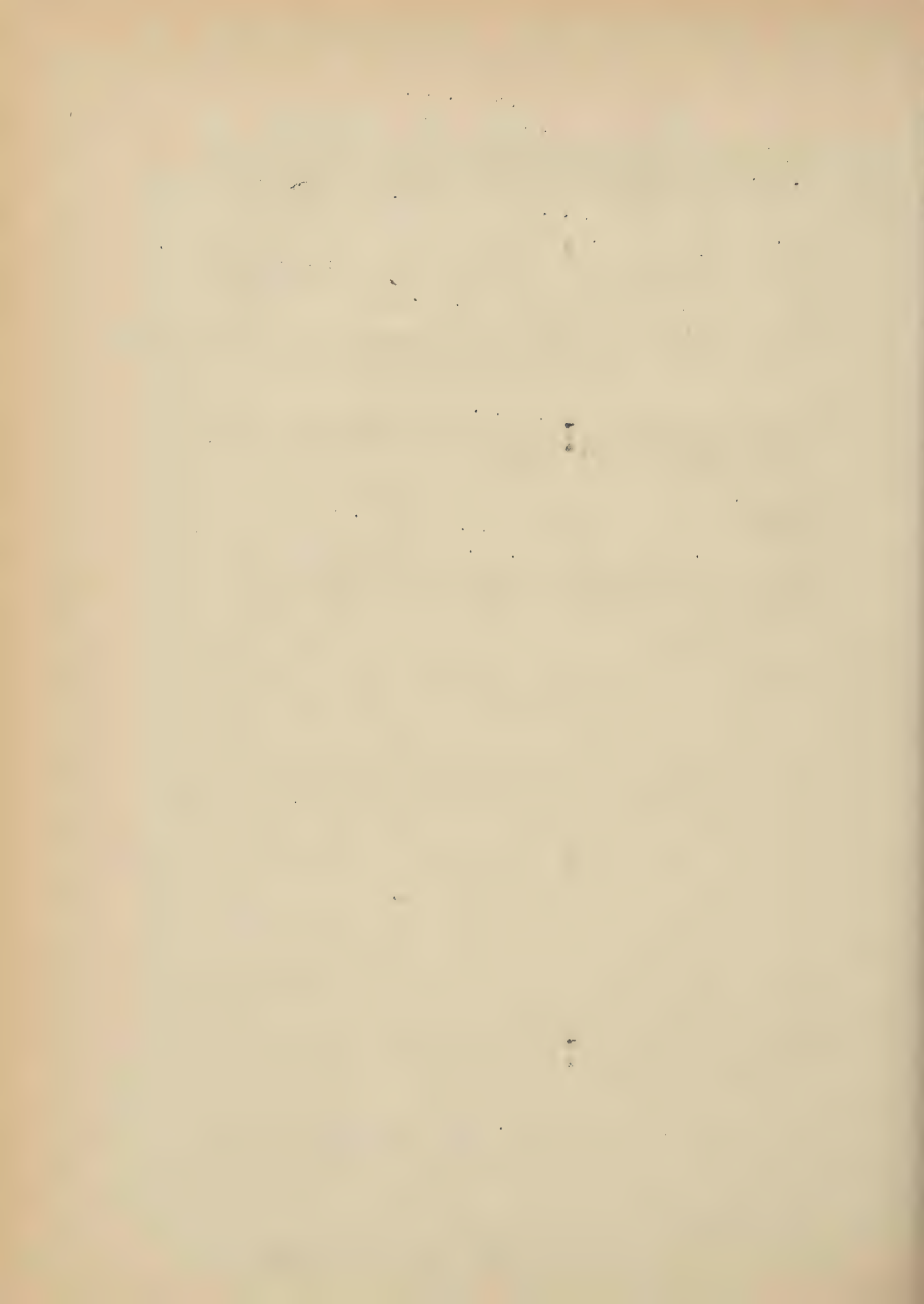
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CHAPTER IV

MISCELLANEOUS LITTERS AND LITTER ADAPTERS

Section 2

Development Project, F-29

Ambulance, Snow & Ice

I. Introduction.

The impracticability of the hand-carry method in over-the-snow evacuation provided the stimulus not only for extensive experimentation with various types of ski-litter conversions, but also with a wide variety of sleds, toboggans, and snow trailers. No doubt such improvisations were resorted to at a relatively early date in American military history. The tendency, however, to think in terms of a specialized winter conveyance designed expressly for Medical Department use, appears to have been of comparatively recent origin. It was not, in fact, until 1943 that a formal development project was established by The Surgeon General's Office to produce such an item.

In the years immediately preceding the initiation of Development Project, F-29, five different kinds of over-the-snow devices were considered by medical research and development personnel. Brief mention will be made of each of these experimental items, inasmuch as certain of the decisions reached in their connection had a definite effect on the more formal research activities that followed.

A. The Pico Rescue Sled.

On 18 March 1941, the Experimental Board of the Alaskan Defense Command submitted a formal test report on the Pico Rescue Sled, manufactured by Harvey N. Smith, North Clarendon, Vermont.¹ The sled was of wood construction, 22 inches wide and 81 inches long, with wooden runners which were turned up at both ends. The runners were 3 inches wide, with a flat surface 54 inches long, giving a total bearing surface on level ground of 162 square inches per runner. The 4-inch sides of the sled could be lowered to the bed, which was 9 inches above the ground and removable. Along each side of the sled a 7-foot bamboo pole was inserted in rings in the framework. It was contemplated that these poles could be used as handles, permitting the sled to be carried as a litter, or that one pole could be removed and used as a G-pole

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for steering. The sled alone weighed $28\frac{1}{2}$ pounds, the special litter which had been provided for it weighed $11\frac{1}{2}$ pounds, making a combined unit weight of 40 pounds. Cost of the sled was \$100.00.

The bulk of the testing was performed at Ladd Field under temperatures ranging from 0 degrees Fahrenheit to 15 degrees Fahrenheit. Snow was from 12 to 24 inches in depth, and was dry and firmly packed. The sled was tested over roads, trails, unbroken snow, and ice-covered rivers. It was pulled by men on foot, on snowshoes, and on skis, and was also towed by motor transportation. These comprehensive tests disclosed a number of defects in the Pico Rescue Sled, as well as a number of disadvantages inherent in the use of sleds generally for evacuation purposes. The Board, however, expressed the belief that a sled similar in construction to the one under examination, but with certain important modifications, would be both desirable and practical as a supplementary evacuation item.

In general, the recommendations for re-design of the Pico model were aimed at adapting the sled for use with the standard aluminum litter in place of the non-regulation wood litter which had been furnished by the manufacturer. On the assumption that this conversion could be satisfactorily accomplished, it was further recommended that an appropriate number of the new sleds be routinely provided for all medical detachments of infantry regiments operating in ice and snow. On the negative side it was pointed out that, while the proposed modified sled could be easily pulled by hand, it was not suitable for towing by motor transportation. It was also noted that the sled-type of conveyance still left unsolved the problem of providing suitable protective covering for patients being evacuated during sleet, hail, or snow storms, and in cold, driving rain.

B. The Commerical Type Toboggan.

At the same time that the Pico Rescue Sled was being tested, the Alaskan Experimental Board also subjected to test a standard, commerical type toboggan.² The frame, which was made of hardwood strips turned up at the front, followed the conventional design. It was 16 inches wide, 8 feet long, and weighed 26 pounds, empty. No litter was provided and there were no special fittings for litter adaptation. The cost was \$12.00.

The field tests which were performed were identical with those which had been employed in testing the rescue sled. The results obtained in the present instance, however, were strikingly negative. In the first place, the toboggan was found to be unsatisfactory for carrying casualties over

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soft snow. The snow not only piled up and came over the front of the toboggan, but came in the sides also and worked up under the patient. On a hard-packed snow trail, on the other hand, the toboggan proved to be very rough riding because of its continual flexing along the longitudinal axis. Finally, although lighter than the rescue sled (26 pounds as against 40 pounds), the toboggan did not pull easier and, as procured, was also too narrow to accommodate an average sized man, adequately covered.

Accordingly it was recommended that the commercial type toboggan, used alone and unequipped with litter fittings, be rejected as a means for the over-the snow transportation of Army wounded.

C. The Snocraft Folding Sled.

In 1941 a variation on the Pico Rescue Sled design, a folding sled manufactured by Snocraft, Incorporated, Norway, Maine, was tested by the 5th Division stationed at Camp McCoy, Wisconsin.³ The folding feature made it possible to transport the sled by horse or mule when not required for medical service. The original model, however, was found to be too short to be practicable for general use in casualty evacuation. The logical next step, a lengthening of the folding sled, was taken during 1942. The Mountain and Winter Warfare Board, Camp Hale, Colorado, one of whose members had seen the Snocraft sled in operation at Camp McCoy, arranged with the manufacturer to have the same collapsible sled produced in an eight-foot length.⁴ Upon completion this modified model was requisitioned on an experimental basis for use by the 87th Infantry Division Mountain. Inasmuch as this unit was supplied entirely by pack animals, all of its equipment had to be adaptable to that type of transportation.⁵ The folding sled, therefore, appeared to be a satisfactory expedient.

D. Cargo Carrier, Light, U. S. T-15.

An evaluation of the weasel-type tractor, both as an evacuation vehicle and as a towing device, was made by the Planning Division of The Surgeon General's Office on 1 January 1943. Because of the subsequent importance of the tractor type of vehicle in winter evacuation, the relevant portions of that report are quoted below.

The Cargo Carrier, Light, U. S. T-15, OSRD designation "Weasel" has been examined and inspected by this division and is not believed suitable for use as a small ambulance for the following reasons:

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a. There is insufficient room for patients in the vehicle, it being not much larger than a jeep. If patients were placed on toboggans towed by this vehicle, they would be subjected to increased hazards and cold.

b. Cases of shock and fracture would be aggravated due to the pitch fore and aft of this vehicle making it very rough riding, it being necessary to fasten the driver and passenger in with belts similar to an airplane belt.

c. Studies are being made by the Ground Forces and Equipment Laboratory to develop a satisfactory snow ambulance.⁶

As we shall see presently, in 1944 extensive field examination was made of the M29 Cargo Carrier, a much larger type of tractor, and, as a result, adoption of this vehicle for over-the-snow evacuation was recommended by Army Ground Force authorities. Whether, therefore, sufficient exploratory study of the tracked type vehicle was made by the Medical Department prior to the initiation of Development Project, F-29, is a question which may well be pondered in attempting any final evaluation of this project as a whole.

E. The Franklin Toboggan.

On 3 February 1943, the Quartermaster Corps forwarded to The Surgeon General's Office an emergency rescue toboggan which had been submitted by O. M. Franklin of Wenatchee, Washington.⁷ The toboggan was duly transferred to the Medical Department Equipment Laboratory at Carlisle, Pennsylvania for field testing, and a formal report of findings was rendered by that installation on 8 March 1943.⁸ The Franklin toboggan consisted of a series of plywood sections, $\frac{1}{4}$ inch in thickness, which were hinged together by means of two $2\frac{1}{4}$ inch web straps. The rear edges of the plywood strips overlapped slightly and were covered with light metal. The front of the toboggan was a curved piece of sheet metal. Straps on the front and rear served to hold a pair of skis, which had been added to give rigidity. When opened the toboggan measured 20 inches by 6 feet 9 inches, but could be folded up into a space approximately 16 by 20 by 8 inches. Total weight, without skis, was $14\frac{1}{3}$ pounds.

The Laboratory's report, which contained general conclusions rather than detailed test results, was as follows:

a. Advantages: It is light in weight, folds

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readily and can be transported on pack rack or back.

b. Disadvantages:- It requires the use of a pair of skis to give it the necessary support. The materials used and construction are too weak for service. It rides too low in the snow causing the patient and coverings to become wet.

While a toboggan can be used to transport patients in snow, it is necessary to have a basket type or else have means of attaching a litter so as to keep the patient out of the snow. Toboggans are hard to pull in soft snow and hard to keep on the trail, especially if down hill without being held from the rear. Some type of sleigh or litter on skis is preferable.

The adoption of the subject collapsible toboggan as standard Medical Equipment is not recommended.⁹

F. Summary.

The conclusions which were reached by the Medical Department, as a result of the aforementioned field tests and laboratory examinations of various types of winter evacuation equipment, are listed below in summary form. As we shall see presently, these findings played an important part in the establishment of Development Project, F-29, in the formulation of project objectives, and in the selection of appropriate military characteristics for the proposed new item.

1. Sleds (straight and folding)

Straight and folding sleds could be readily designed to accommodate the standard aluminum litter. So designed, they could be satisfactorily employed in over-the-snow evacuation by medical corpsmen equipped with skis or snowshoes, or proceeding on foot. The disadvantages of the method were: (1) The patient was exposed to the elements; (2) considerable personnel was required to carry out the operation; (3) sleds were not well adapted to alternative means of evacuation, such as towing by motor transport or by pack animal. In any event, so far as the sleds themselves were concerned, further development work did not appear to be necessary. So long as future Quartermaster models were adaptable to the standard Medical Department litters, no additional fittings or adjustments were needed.

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2. Toboggans (straight and folding).

All of the disadvantages listed above applied with equal force to the use of toboggans in winter evacuation. In this instance, however, an even more basic difficulty had been encountered. In its present form the toboggan was of little or no value to the Medical Department. To bring this item of equipment to a point of medical usefulness equal to that of the sled, it would be necessary to devise adapters which would not only accommodate the toboggan to the standard litter, but would at the same time raise the litter sufficiently high off the ground to prevent snow from packing in around the patient and to insure a reasonably comfortable ride. Significantly, although this was not one of the announced purposes of Development Project, F-29, the design and construction of a suitable toboggan adapter was one of the project's earliest tangible accomplishments.

3. Motor Transport (The T-15 Weasel).

Because of the desirability, in cold weather operations, of greater patient protection and more speedy evacuation than could be afforded by either the hand-drawn sled or toboggan, the Medical Department had turned its attention briefly to motor transport. The T-15 Weasel, one of several powered vehicles capable of functioning efficiently in deep snow and over frozen mountainous terrain, was examined and found unsuitable for carrying litter patients. No further consideration was given to the possibility of rigging this so-called "prime mover" type of vehicle for casualty evacuation. It was suggested, however, that, since snow tractors were not themselves adaptable to safe and comfortable patient carry, some type of all-purpose trailer might offer a promising research alternative.

4. The Snow and Ice Ambulance (Development Project, F-29).

The evolution of Medical Department thinking, from a one-litter sled type of evacuation device to a two or three-litter cart or sleigh, is wholly understandable from the data which has just been examined. Gradually it had appeared that what was needed, either to supplement or supplant the conventional sled or toboggan, was an item which would: (1) be large enough to accommodate more than one litter patient, thus speeding up the evacuation process yet conserving personnel; (2) be light enough to be hand drawn when necessary, and so be available for use in forward areas; (3) be, at the same time, sufficiently heavy and stable to permit towing by pack animal or powered transport; (4) provide maximum cover and warmth for the patient.

The above criteria were, as we shall see, soon adopted without serious modification as basic military

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characteristics of the proposed snow and ice ambulance. As in the case of the ski litter adapter, however, this concept of a lightweight cart or sleigh had not developed overnight but had grown gradually over a period of years. Whether or not the idea thus evolved was to be as practicable as it was logical will be seen from the account that follows.

II. Project Initiation.

On 22 February 1943, as mentioned in the previous chapter, a conference was held at The Surgeon General's Office on the subject: Cold Weather Operations and Application for Medical Equipment to Such Operations.¹⁰ At this meeting the Director of the Equipment Laboratory discussed, among other things, the need for a lightweight sleigh not only for snow and ice conditions generally but also as a specialized item of equipment for light Alpine divisions. The various ways in which the proposed sleigh could be used to supplement existing evacuation devices were described in some detail.¹¹

Less than a week later the Equipment Laboratory submitted to The Surgeon General's Office the following written recommendation for the initiation of a new winter equipment project:

1. It is believed desirable to set up a project on development of sleds and other means of transport for winter warfare.
2. The funds necessary should be approximately \$1,000.00¹²

The above information, in view of the highly specific requirements of AR 850-25 governing project initiation, was scarcely adequate. On 3 March 1943, The Surgeon General's Office replied as follows:

1. The Research and Development Division requests a more specific and complete statement on the items to be developed with reference to paragraph 1, basic communication, be furnished this office.
2. They also raised the question as to whether funds requested will be sufficient for this project.¹³

This letter produced the desired results for, on 8 March 1943, the Equipment Laboratory re-submitted its

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proposal, this time giving complete and detailed information. Two separate projects were now recommended; one to develop a ski litter, and the other to develop a snow and ice ambulance. With respect to the latter, the following data were presented:

- a. Purpose of initiating this project. To determine the feasibility of some type of sled, sleigh, toboggan or similar device for the emergency transportation of at least two casualties over terrain covered with ice and snow.
- b. History. Preliminary investigation has revealed that no such project has been conducted by this laboratory.
- c. Plan for Fiscal Year 1943. To develop an ambulance which will be light in weight, easily transported, capable of carrying at least two recumbent patients over terrain covered with ice and snow. This ambulance to be on the order or of a type similar to a sleigh, sled and/or toboggan. Final type to be determined after experimentation.
- d. Military characteristics (tentative).
 - (1) To provide for the carrying of at least two litter patients.
 - (2) To be of light weight and easily transported.
 - (3) To be inexpensive and easily procured.
 - (4) To be so designed that it can be pulled by a mount, small tractor, or if necessary by human hand.¹⁴

It was further recommended that \$800.00 be made available from current funds to finance the project.¹⁵

Informal approval of Headquarters, Army Service Forces, to initiate Development Project, F-29, "Ambulance, Snow and Ice," was received by The Surgeon General's Office on 13 March 1943.¹⁶ Since only routine processing procedures remained to be completed, the Equipment Laboratory was notified that work on the project could begin immediately. At the same time it was recommended that the Laboratory's estimate of the funds needed to conduct the experimentation be increased from \$800.00 to \$2,000.00.¹⁷

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Formal processing of the project proposal was handled quite expeditiously in this instance. On 14 April 1943, the Subcommittee of the Medical Department Technical Committee approved the military characteristics which had been submitted by the Equipment Laboratory, and recommended that the project be initiated.¹⁸ These recommendations were concurred in by the Medical Department Technical Committee on 10 May 1943,¹⁹ three days later the project request was forwarded to Headquarters, Army Service Forces,²⁰ and on 20 May 1943 final Army Service Forces approval was granted.²¹ By the early part of June, all installations concerned had been officially notified of the establishment of the new project.²²

In short, in the subject instance only three and a half months had elapsed from the time of the first Laboratory request for project initiation and final Army Service Forces. In the case of the Ski Litter, nine months had been required for the same procedural operations.

III. Development Phase.

A. Preliminary Research Activities.

While official notification of Army Service Forces action did not reach the Equipment Laboratory until the middle of June, 1943, it will be recalled that on 13 March 1943 the Laboratory had been authorized to begin development work on the strength of informal assurances received from The Surgeon General's Office.²³ In view of the fact that 1 September 1943 had been set as the estimated completion date for Development Project, F-29, it was imperative that preliminary research activities be begun immediately. Accordingly, on 20 March 1943, the Equipment Laboratory wrote to the Office of the Quartermaster General, requesting drawings and specifications of all toboggans and sleds currently being used by the Army.²⁴ Upon receipt of this information a week later,²⁵ the Laboratory prepared a formal requisition for one Military Toboggan, Type I (freight toboggan), one Military Toboggan, Type II (standard toboggan), and all related accessories.²⁶

While awaiting the arrival of the Quartermaster toboggans, the Laboratory established contact with several likely commercial manufacturers and at the same time began work on drafting pilot models of the new snow and ice ambulance.²⁷ During this same period, the Mountain and Winter Warfare Board at Camp Hale, Colorado, and the Commanding Officer of the 2nd Division, stationed at Camp McCoy, Wisconsin, were contacted for technical information and suggestions.²⁸ On 22 April 1943, the details of one ad-

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ditional toboggan type were made available to the Laboratory when The Surgeon General's Office forwarded photographs of the Thaden Sled Toboggan, which was currently in use at the Alaskan Defense Command.²⁹

Upon the receipt of the two Quartermaster toboggans in May, 1943,³⁰ the Laboratory's drafting room activities were greatly intensified. Within a month, ideas for the new snow and ice ambulance had so crystallized that the preliminary period of development work can be considered to have come to an end. From this point on, attention was focussed on the actual factory production of a suitable number of experimental models.

B. Snow and Ice Ambulance (Phase I).

On 12 June 1943, in an informal memorandum the Equipment Laboratory outlined the general physical requirements of the new snow and ice ambulance as follows:

Snow and Ice Ambulance

1. Dimensions:
Inside - 91" x 48" x 48".
2. Construction:
Wood with plywood or masonite interior and exterior panelling. Insulation 1 inch thick between panels.
3. Top to be bow type, removable construction covered with double thickness canvas with insulation between.
4. Height of floor from ground:
9 to 12 inches.
5. Folding seats on each side.
6. Type I
 - a. 2 runners, 4" in width.
 - b. Folding top
 - c. Bows and canvas.
 - d. Trailed by jeep, horse, or tractor.

Type II

- a. 4 runners, front runners to be sled type;
3 - 3½" in width.

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- b. Collapsible top, bows, and canvas.
- c. Trailed by jeep, horse, or tractor.³¹

Before the close of June, negotiations for the construction of the aforementioned two types of snow and ice ambulances (one with two runners and one with four runners) were initiated with the Jerald Sulky Company of Waterloo, Iowa, one of the commercial firms which had previously been contacted by the Laboratory.³² It was anticipated that delivery of the pilot models could be made by 15 August 1943, after which time they would be tested and reported upon to The Surgeon General.³³ In view of the early completion date which had been set for the project, 1 September 1943,³⁴ it was already obvious that an extension of time would be necessary. It will be recalled, from the preceding chapter, that field tests conducted by winter training installations like Camp Hale and the Alaskan Defense Command were often time-consuming in the extreme.

During this experimental production stage, which extended from June, 1943, through October, 1943, an active correspondence was carried on between the Equipment Laboratory and the Jerald Sulky Company. This close working relationship with a private industrial concern was a typical Medical Department research practice throughout the period of World War II. It was a process in which the Laboratory at Carlisle presented basic engineering plans, while the manufacturer suggested improvements or modifications dictated by immediate practical considerations. A concrete illustration of this particular type of collaboration is furnished by the technical discussion and interchange of ideas which occurred with reference to the snow and ice ambulance.³⁵

In mid-June, for example, the Jerald Sulky Company suggested, in view of anticipated difficulties in securing plywood, that Hard Tempered 1/8 inch Masonite be substituted for use on the inside and outside of the sides and front wall of the ambulance. For the floor it was proposed that Insulite board over the sills, with 1/9 inch Masonite on top of the Insulite, would not only insulate the floor but would add strength to it. After subsequent experimentation, however, the company reported that tests of the Masonite Hard Tempered board disclosed that it lacked the strength of the 1/4 inch plywood, and would probably not be satisfactory. Upon investigation it was also learned that, unless the snow and ice ambulance was to be procured in enormous quantities, there was probably sufficient plywood available on the market to satisfy normal demands. These latter findings proved to be essentially valid. While completely waterproof plywood was at a premium before the close of the year, the company was able

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to secure an adequate amount of semi-waterproof material to construct all four pilot models of the snow and ice ambulance.

A question was also raised in regard to the need for double wall canvas with insulation between the walls. The manufacturer pointed out to the Laboratory that, while either kapok or wool lining could be used effectively, insulation of the top of the ambulance represented one of the major items of cost of the ambulance. Several of the expert canvas workers in Waterloo had been consulted, and advised against the construction of such a top, although they were able to produce the item in quantity. The reply of the Laboratory in this instance was as follows:

... Now as to top insulation, I realize that most canvas men do not like to do that sort of work, and it may not be of any particular value but I have a Directive which requires insulation and so we will have to put in something. I believe ordinary blanket lining will be satisfactory; Kapok would be too hard to procure.³⁶

Most of the manufacture's suggestions, of course, met with more success than the two described above. The company proposed that tubular steel axles, both front and rear, be used instead of wood on the grounds that steel was more readily procurable, construction problems would be simpler, the axles would be stronger, and there would be little difference in weight. The Laboratory concurred in this view, providing weight was not increased appreciably, and the tubular steel axles were incorporated into the tentative specifications. The company also redesigned the body sides, so that they would fold down, and made changes in the placing of the front runners (of the four-runner model) to provide adequate clearance for the shaft. Both of these modifications met with the approval of the Equipment Laboratory, as did the suggestions that sled clearance be increased to 15 inches, and that runner-width be reduced to provide a more easily towable trailer. One further suggestion that was rejected at this stage but was later adopted in modified form, was the proposal that the runners be constructed of pressed metal instead of hard wood. Months later, when the first factory models were being inspected, the Director of the Equipment Laboratory recommended that the bottoms of the wood runners be reinforced by a covering of 16 gauge metal.

What has been listed above does not represent an exhaustive enumeration of the changes proposed by the Jerald Sulky Company. However, sufficient detail has been included to indicate the very substantial role this collaborating

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manufacturer played, even after preliminary blueprints had been drawn up by Medical Department personnel. In this instance not all of the company's suggestions were accepted, and certain of those which were approved subsequently turned out to be faulty. However, enough of the manufacturer's ideas were ultimately incorporated in the final test models of the snow and ice ambulance to justify a description of this developmental work as a joint activity.

Costs of manufacture were discussed and agreed upon early in the negotiation period. The Jerald Sulky Company, on 3 July 1943, presented written estimates of \$385.00 for the four-runner ambulance, and \$360.00 for the two-runner model. It was, of course, explained that on a full production run these vehicles could be manufactured for a fraction of the above cost.³⁷ These estimates were approved by the Laboratory,³⁸ and on 16 July 1943 the company received a purchase order for four sleighs, two of each type.³⁹ Difficulties with priorities delayed production of the sleighs, however, several months beyond the originally anticipated date. It was not, in fact, until the project was re-rated with an AA-1 instead AA-3 listing that all necessary materials were procured and fabrication actually begun.⁴⁰ As a result of these delays, the estimated completion date for Development Project, F-29, was extended from 15 August 1943 to 1 January 1944.⁴¹ Even this extension, as we shall see, was far from adequate.

By the early part of October, 1943, one of the pilot models of the snow and ice ambulance was completed, and on 11 October the Director of the Equipment Laboratory inspected this vehicle at the manufacturer's plant at Waterloo, Iowa.⁴² This was the Type II, or four-runner, model and in the informal inspection report the following changes were recommended by the laboratory Director:

1. Lengthen rear runners 46 to 48".
2. Build the front of the runners 2 to 2½" higher.
3. Make all runners 5" wide.
4. Cover bottom of runners with 16 gauge metal.
5. Hinge seats up instead of down.
6. Insert 6 x 9 ventilator in front of

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canvas.⁴³

While the above changes were being accomplished by the Jerald Sulky Company, and while construction was being continued on the Type I (two runner) snow and ice ambulance, a wholly different development suddenly took the center of the stage. Under the sponsorship of the Equipment Laboratory a new type of toboggan adapter was now submitted to The Surgeon General's Office for its consideration.

C. Adapter, Toboggan, Litter.

On 23 October 1943, the Medical Department Equipment Laboratory forwarded to The Surgeon General's Office drawings, specifications, and photographs of a toboggan litter adapter (see Figure 17) which had been developed by the Laboratory. It was stated that the adapter made feasible the usage of the standard litter with the standard toboggan, thus providing an additional means for the transportation of wounded. It was the opinion of the Laboratory that the toboggan adapter might be of value in those units in which the aforementioned equipment items were available.⁴⁴ The Surgeon General's Office, after a brief study, concurred in the above views and, on 1 November 1943, forwarded all the relevant data to Army Ground Forces for its remarks and recommendations and for suggestion as to an appropriate basis of issue.⁴⁵

The reply from Army War College, Army Ground Forces, dated 13 December 1943, was as follows:

1. Adapter, Toboggan, Litter, is believed to be an essential item of equipment for use of the standard litter in conjunction with the Standard toboggan as a means of transportation of casualties over snow.

2. It is requested that action be initiated to standardize the adapter and a basis of issue established for troops engaged in winter training as follows:

140 - *Per Division engaged in winter training.

(*For use of medical units engaged in evacuation of sick or wounded patients over snow-covered terrain.)

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3. While the total requirement for Adapters, Toboggan, Litter is 140 at the present time, any additional requirement predicated on organization issue of this item, will be furnished Army Service Forces at a later date.

4. When the Adapter, toboggan, litter is standardized, an appropriate amendment will be published by this headquarters to letter, Headquarters, Army Ground Forces, dated 30 September 43, file No. 420 (C) (30 Sep 43) -GNGDS-3A, subject: Winter Clothing and Equipment to the Commanding General, Second Army.⁴⁶

Upon receipt of the above concurrence, the Plans Division of The Surgeon General's Office immediately recommended to the Medical Department Technical Committee that the toboggan litter adapter be classified as "required type, development type, Service test type," and that 300 units be purchased for service test by two Light Divisions engaged in winter training.⁴⁷ Since the military characteristics which had been established for the snow and ice ambulance, specifying among other things at least a two-casualty carrying capacity, could not be applied to the toboggan litter, a new set of military characteristics had to be formulated for the subject development. Accordingly, the following statement was forwarded by the Plans Division to the Medical Department Technical Committee:

It is recommended that tentative Military Characteristics for subject item (Adapter, Toboggan, Litter) be as follows:

a. To provide a means of fastening a standard litter to a standard toboggan in such a manner as to provide an adequate means for the transportation of wounded.⁴⁸

These recommendations of the Plans Division were followed by the Subcommittee of the Medical Department Technical Committee, at a meeting held 21 December 1943, in all but two important respects. First, instead of approving the classification of the new adapter as a development and service test type, thus providing for extensive field trials before acceptance as a standard equipment item, the Subcommittee proposed immediate classification as "required type, adopted type, standard article." Apparently there was

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a more urgent need for the new adapter than had been originally anticipated. Secondly, quantity requirements were increased from 140, as initially recommended by Army Ground Forces, to 484 adapters for 1944 and 185 for 1945. Under quantity procurement, unit cost (1 adapter to constitute 1 unit; basis of issue to be 2 adapters per toboggan authorized for medical troops) was estimated at \$1.75, making a total purchase cost for 1944 of \$864.50, and for 1945 \$323.75.⁴⁹ These latter estimates, it may be observed, proved to be rather optimistic. Actual unit cost on the final purchase order, dated 15 March 1944, amounted to \$10.92 instead of \$1.75. Consequently, even though quantity requirements were subsequently reduced to 300, a total outlay of more than \$3,200 was involved.⁵⁰

On 19 January 1944, Subcommittee recommendations were approved without change by the Medical Department Technical Committee.⁵¹ On the following day, all standardization data was forwarded to Headquarters, Army Service Forces, for final approval. The toboggan litter adapter was described as follows:

This item consists of two pairs of shoes secured to opposite eyebolts at each end of a standard Quartermaster Department toboggan, supporting two cross bars upon which rest the standard litter. The stirrups of the litter are secured by strap and buckle to each of the four shoes.⁵²

Little delay was encountered in obtaining final acceptance of the toboggan adapter. On 29 January 1944, Army Service Forces approved the Medical Department's request for standardization of the item,⁵³ and before the close of the month all officers concerned had been officially notified of this action and advised to begin processing the new article for procurement.⁵⁴ On 15 March 1944, a purchase order for 300 of the toboggan adapters, at a unit cost of \$10.92, was formally placed by the Army Medical Purchasing Office at New York City. Although it had been originally estimated that over 1,000 adapters would be needed during 1944 and 1945, as of 26 July 1945 no further production orders had been placed.⁵⁵

The foregoing development of a toboggan litter adapter is noteworthy in several respects. First of all, although the adapter was officially listed as a product of Development Project, F-29,⁵⁶ it was, judging from the records in the case, an unexpected by-product of that investigation. It is true, as we have seen in

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our introductory section, that experimentation conducted between 1941 and 1943 had indicated the need for some kind of attachment which would: (1) fit the standard Medical Department litter; and (2) raise the patient high enough above the toboggan surface to insure protection from the snow. However, when Development Project, F-29 was initiated, there was no indication in the military characteristics which were proposed at that time that a toboggan adapter for single casualty carry was contemplated. The demand, evidenced by the firm requirement subsequently cited by Army Ground Forces, had simply arisen suddenly and unexpectedly.

Because of the suddenness of the demand for a toboggan litter adapter, the time available for its development was necessarily short. This primary need for speed, therefore, serves to explain in large part why no report of field tests was prepared by the Equipment Laboratory, and why the recommendation of the Plans Division of The Surgeon General's Office that the new item be tentatively classified as a development type and subjected to service test before final adoption, was vetoed by the Medical Department Technical Committee in favor of immediate standardization. A further indication of the haste with which the adapter was processed is contained in the fact that Subcommittee estimates as to the probably unit cost of the item in quantity production turned out to be less than one-sixth of the cost figure subsequently arrived at in the final purchase order negotiated by procurement authorities.

However, despite these shortcomings, which were themselves largely inherent in the situation, research and development personnel had done a rather remarkable job. The ski adapter, a considerably less complex mechanism, had been under development for more than a year and a half before it was ready for adoption. The toboggan adapter, on the other hand, had been designed, constructed, standardized, and procured in less than six months' time.

D. Snow and Ice Ambulance (Phase II).

By the end of November, 1943, the Jerald Sulky Company had not only completed the refabrication of snow and ice ambulance, Type II, according to the modified specifications drawn up by the Equipment Laboratory, but had also virtually finished production of the Type I (two runner) ambulance.⁵⁷ Accordingly,

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on 25 November 1943, the Equipment Laboratory sent the following communication to The Surgeon General's Office:

The ambulance sleighs now being manufactured at Waterloo, Iowa, are about ready for testing. Information is desired as to where these should be sent.

There has been built two of each type: two - two-runner, and two-four-runner sleighs.

No attempt has been made to heat these but both types are well insulated and may require a little. It is believed, however, that a small blast heater could be added later, when available, to be used especially when tractor-drawn. The heating unit also could be operated by our small 500-watt light generator if necessary. The matter of heating can be arranged later⁵⁸.

The above communication was duly forwarded to Army Ground Forces which replied, on 20 December 1943, that the experimental sleighs should be shipped to Camp Hale, Colorado where they would be tested by the Mountain and Winter Warfare Board. It was requested that test data and questionnaires be forwarded to Army War College by The Surgeon General's Office so that suitable test directive could be issued to the Camp Hale board.⁵⁹ Accordingly, on 29 December 1943, the Equipment Laboratory prepared a comprehensive test data sheet, the most important sections of which are quoted below.

5. Basic reason for this project and objective of test: To develop a light conveyance to transport two litter cases under conditions of snow and ice, to be hauled by man, mule or light tractor which can be readily knocked down for storage or shipment; as light as possible in weight and which does not require critical materials.
6. Suggested outline of test:
 - a. Suitability as regards space, comfort and ease of loading and unloading for two litter cases or

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- four sitting cases.
- b. Ruggedness of construction for ordinary usage.
- c. Suitability for:
 - (1) Mountain and rough terrain.
 - (2) Ordinary cross-country use on moderately level terrain.
- d. Suitability for use on:
 - (1) Ice and packed snow covered trails.
 - (2) Loose powdery snow.
 - (3) Moderately deep snow, moderately packed.
- e. Can they be pulled short distances by ordinary litter squad on snow shoes or skis over various types of snow and ice.
- f. Sufficiency of runners with regards to height for clearance and width and length for road bearing surface.
- g. Sufficiency of cover for wind, rain and snow resistance.
- h. Stability of vehicles; are they readily upset or not.
- i. Are shafts for single animal suitable.
- j. Suitability of ventilation.
- k. Is adjustable feature of top desirable.⁶⁰

On 18 January 1944, The Surgeon General's Office forwarded the above test data to Headquarters, Army Ground Forces, stated that both types of snow and ice ambulance had been shipped to Camp Hale, Colorado, and requested that a report of the field trials be rendered as soon as possible.⁶¹ Accordingly, two weeks later a formal test directive, based largely on the recommendations of the Equipment Laboratory, was prepared by Army War College and sent to the President of the Mountain and Winter Warfare Board. Attention was called to the fact that the test project had been assigned an "A" priority, so that a final decision regarding the subject vehicles could be reached at any early date.⁶² Immediately upon receipt of this directive, the Mountain and Winter Warfare Board at Camp Hale initiated a comprehensive testing program, which was completed 14 April 1944. In the early part of May, 1944, an official report of test findings was sent by the Board to Headquarters, Army Ground Forces.⁶³

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The two types of snow and ice ambulances (see Figures 18 and 19) which had been shipped to Camp Hale by the Equipment Laboratory were identical in a number of respects. The bodies of each trailer were the same, measuring 94 inches in length, $50\frac{1}{2}$ inches in width, and $19\frac{3}{4}$ inches in depth, with a cubic carrying capacity of 45 cubic feet. Two 12-inch folding seats running the length of the insulated body, were provided in each instance. Each trailer body was equipped with an adjustable padded canvas top which was supported by five bows which fit into $\frac{3}{4}$ inch pipes spaced equidistantly along the sides of the frame. Ski runners were covered with $\frac{1}{16}$ inch steel plate, and the stanchions supporting the sleigh body were constructed of 2 inch angle iron and $1\frac{1}{4}$ inch bar stock. Individual drawbars were constructed of one inch and $1\frac{7}{16}$ inch iron pipe. No keels were provided.⁶⁴

The Type I ambulance was distinguishable by its single continuous runners extending the full length of the sleigh on each side, each runner being 100 inches long. The Type II ambulance, on the other hand, was equipped with four separate ski runners attached individually to the sleigh in a manner which allowed each ski to pivot freely in a vertical plane. The two rear runners were 42 inches long, while front runners measured 36 inches in length. The front runners were joined by an offset axle attached to the sleigh by means of a king pin, so that the ambulance could be steered with greater facility. Both ambulance models were designed to carry two litter cases or four sitting cases and were adaptable for towing either by manpower or by snow tractor. A set of shafts, 128 inches in length, had been provided for use with the Type II ambulance so that animal power could be utilized in the towing if desired.

The above two types of snow and ice ambulance were tested by the Mountain and Winter Warfare Board in comparison with a third item--a 1-Ton Snow Trailer, M19, manufactured by the Allis Chalmers Manufacturing Company. The trailer body of this ambulance was 1 inch shorter, $2\frac{1}{2}$ inches narrower, and $6\frac{3}{4}$ inches shallower than the Equipment Laboratory models. Otherwise its most distinguishable feature was its interchangeable skis and wheels, and the manner in which the two ski runners were individually attached to the sleigh, allowing them to pivot freely in a vertical plane. The M19 was not, however, equipped with seats, its padded canvas cover weighed approximately 60 pounds more than the Type I and II ambulance covers, and over-all weight of the vehicle was 650 pounds, as against 450 and 425

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pounds respectively for the Laboratory models.

The two-month field test of these three vehicles was divided into three phases: (1) study of the suitability of design; (2) analysis of the durability of the vehicles; and (3) evaluation of the overall comfort of the ambulances for the patient. During the period of the tests, all paved roads were free of snow a greater part of the time, thereby necessitating the dragging of the sleighs over paved surfaces and bare ground on occasion. The minimum temperature recorded during the test period was 15 degrees below zero Fahrenheit; the maximum temperature was 46 degrees above zero. Both the Cargo Carriers M28 and M29 were employed as prime movers, and each ambulance was towed distances varying between 70 and 120 miles. Cargo loads consisting of medical equipment up to 1,500 pounds in weight were carried. Casualty loads consisting of as many as six sitting patients plus personal equipment were also transported in the ambulances.

The detailed findings of the Mountain and Winter Warfare Board, as a result of these extensive field trials, may be summarized as follows:

1. Space and ease of loading and unloading.

It was found that all three models contained sufficient space for two litter cases or four sitting cases (seats were improvised for the M19 Snow Trailer). Ease of loading and unloading was satisfactory in all instances.

2. Suitability for use on: (a) Mountain and rough terrain; (b) Cross-country and level terrain.

The Type I ambulance was found to be the least suitable for use on any type of snow covered terrain. It was rough riding, broke down on sharp irregularities of terrain, and lacked sufficient maneuverability on turns and sharp corners. The method of ski suspension of the Type II ambulance provided for greater maneuverability on all types of terrain, but it was insufficiently durable to withstand constant use in mountainous country.

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Neither type could be backed up, due to lack of upbend at the rear of the runners. Neither Type I or Type II was suitable for towing over bare ground or paved roads, since only skis were provided. The 1-Ton Snow Trailer was found to be the most suitable of all for use on various types of terrain. The shape and manner of suspending the skis made it highly maneuverable over cross-country terrain and rough trails alike.

3. Suitability for use on: (a) Loose, powder snow; (b) Moderately packed snow; (c) Packed snow and ice-covered trails.

Flotation and ground pressure provided by the runners of the three types of ambulances indicated that, while the greatest amount of flotation was provided by the Type I vehicle, use of a prime mover made a sufficiently packed trail for the effective operation of all types. Due to excessive slowing caused by the lack of a keel, the Types I and II models had to be operated with extreme care on ice-covered and hard packed snow trails.

4. Suitability for employing various power sources.

It was found that the Types I and II ambulances could be manhandled for short distances if empty or carrying not more than one patient. Manhandling these vehicles for distances greater than a few yards, however, was not practicable. The Type II ambulance, which was equipped with shafts, could be dragged with ease by one animal, providing the snow surface was sufficiently hard packed to hold up the animal. The Cargo Carriers M28 and M29 served as satisfactory prime movers for the Laboratory models, and the M28 for the M19 Snow Trailer. The pintle of the M29 was

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too high to be satisfactory for towing the M19.

5. Adequacy of runners as regards: (a) Slowing; (b) Clearance; (c) Flotation.

The flotation and clearance of all three types of ambulance was found to be satisfactory, although slewing was excessive with Types I and II due to their lack of keels. The runners of the M19 Snow Trailer were equipped with 3/4-inch keels which prevented side-slipping on hard packed snow and ice surfaces.

6. Durability of the subject ambulances.

It was found that the Types I and II ambulances were not sufficiently durable to withstand continued mountain use. The following failures and breakages occurred: (1) runners and stanchions were damaged and broken after being towed over rough snow-covered mountain trails; (2) breakages in the drawbar and lunette occurred in most cases at the same time as those of the runners; (3) cover bows and cover bow supports were found to be insufficiently durable; all were bent, and several bow supports were broken off completely.

No breakages or failures of any part of the M19 Snow Trailer occurred during the period of test.

7. The comfort afforded the patient by the subject ambulances.

It was found that the difference in warmth and comfort afforded the patient by moving the top of the Types I and II ambulances to the lower position was negligible. Since no means of providing for heating, the warmth provided by sleeping bags remained approximately the same regardless of the position of the top.

It was found that the greatest riding comfort was afforded by the M19, while Type I was the least

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comfortable of the three. The models utilizing a pivoting ski runner provided the smoothest ride in that the skis could follow the contours and irregularities in the trail. The M19 equipped with but two ski runners, was superior to the type equipped with the four pivoting runners, as the runners of the former sleigh were of necessity in contact with the snow surface at all times.

Ventilation was found to be adequate in most cases, although patients occasionally complained of the odor of fumes from the exhaust of the prime mover.

The covers for the Types I and II ambulances were found to be an adequate means of protection against wind and snow. While no means was provided for letting in light, the exclusion of windows eliminated what would otherwise be a source of drafts. The cover for the M19 weighed approximately 60 pounds in excess of the weight of the covers of the other two models. Not only was the weight of this cover found to be excessive, but the method of attachment was awkward and insecure. The hook and cord arrangement (as against snap fasteners) was unsatisfactory, as many hooks broke off or bent, and the closure around windows was not sufficient to keep out drafts.

The provision for light and heat in the M19 Snow Trailer was found to be a distinct advantage in contributing to the patient's comfort, and was the incorporation of a small keel on the runners of this sleigh. The interchangeability of skis with wheels was a distinct gain for maneuverability.

On the basis of the above findings, the Mountain and Winter Warfare Board submitted its initial conclusions as follows:

- a. The Snow and Ice Ambulances, Types I and II, are not suitable for use due

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to their fragile construction and faulty design.

- b. The 1-Ton Snow Trailer, M19, is the most suitable of the three types of sled-ambulances tested.⁶⁵

It will be noted however, that the M19 could not be manhandled and, therefore, did not fulfill the military characteristics as originally set forth for the snow and ice ambulance. On the other hand, while the Types I and II ambulances could be towed by hand for a few yards, they were deemed too insubstantial for actual mountain use. This, of course, raised the question of the practicability of the military characteristics themselves. The Board's judgment on that point was highly explicit,

The basic reason for this project and the objective of test were "to develop a light conveyance to transport two litter cases under conditions of snow and ice, to be hauled by man, mule, or light tractor, and which can be readily knocked down for storage or shipment; as light as possible in weight and which does not require critical materials." A vehicle light enough to be towed by men will lack durability when towed by a snow vehicle. The extent of snow covered terrain over which mules can operate is in general too limited to warrant the use of mules for the towing of an ambulance sled.⁶⁶

The project purpose was, therefore, in the Board's opinion, unattainable. More than that, the Board went on to declare that, even if practicable, there was little or no military requirement for such an item.

It is the opinion of the medical personnel at Camp Hale that no requirement exists for a towed snow and ice ambulance for use in mountainous terrain. The Board agrees with the medical authorities at this station insofar as use in mountainous terrain is concerned, but will not go on record in making a positive statement that no requirement exists for a towed snow and ice ambulance for use on flat or rolling snow covered terrain.⁶⁷

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The reason for the Board's negative recommendation with regard to the trailer type of snow and ice ambulance was its belief that the Cargo Carrier, M29, which had been used as one of the prime movers in the tests just completed, was itself entirely suitable as an evacuation vehicle.

The Cargo Carrier, M29, can be successfully employed as an over-the-snow ambulance without modification to carry one litter case and leave two vacant seats for slightly wounded or medical personnel. By the use of special brackets the Cargo Carrier, M29, can be adapted to carry two litters, leaving space for one extra passenger. This vehicle, so employed, is superior to the three types of sled ambulances tested in fulfilling the various military characteristics enumerated in para 6 a above, and possess the additional advantage of providing its own power. If the prime mover is, in itself, a highly satisfactory ambulance, the towed vehicle cannot be tested without also giving serious consideration to the self-propelled ambulance.⁶⁸

In short, a full-track type of vehicle was now being recommended by the Mountain and Winter Warfare Board as the ideal instrument for mountain evacuation. It was stated that the M29 was tactically capable of fulfilling virtually all needs for vehicular evacuation between collecting and clearing stations. In those abnormal circumstances where collecting stations were in a position to use an ambulance sled in addition to the M29, it was pointed out that the ordinary means of evacuation could be supplemented by use of the regulation cargo sled. Thus, no new developmental items were needed.

The Board's final recommendations were two in number: (1) That no further consideration be given the Snow and Ice Ambulances, Types I and II; (2) That the Cargo Carrier, M29, supplemented when necessary by the regulation cargo sled, should satisfy all medical requirements for evacuation over mountainous and snow covered terrain.

The above test report was forwarded to the Ground Requirements Section, Army Ground Forces, on 3 May 1944.⁶⁹ On 20 May 1944, Army Ground Forces relayed two copies of the Board report to the Research and Development Division, Army Service Forces, with the following comments:

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2. The Recommendations contained in paragraph 8 are approved.

3. Inasmuch as the M29 Cargo Carrier is a satisfactory vehicle for evacuating sick and wounded, no further consideration should be given to a special vehicle for this purpose. In a case of necessity the standard Cargo Sled can be rigged for carrying litters and used over flat or rolling, snow-covered terrain.⁷⁰

Several days later, Army Service Forces added its concurrence to that of the Ground Forces.⁷¹ The Mountain and Winter Warfare Board's findings and conclusions were encountering little opposition. It was, moreover, soon apparent that even The Surgeon General's Office had no objections to offer.

In consideration of previous indorsement (ASF), paragraph two and three of second indorsement, prepared by Ground Forces, this office will consider Development Project F-29 as discontinued.⁷²

On 5 June 1944, the Equipment Laboratory itself admitted the soundness of the Mountain and Winter Warfare Board's recommendations.

Discontinuance of this project is recommended inasmuch as a sled ambulance durable enough to meet mountain requirements would be too cumbersome and heavy to be of any general use.⁷³

E. Modification of Adapter, Toboggan, Litter.

The toboggan litter adapter which, it will be recalled, had been standardized 29 January 1944, had been designed to fit only the regulation military toboggan. On 5 May 1944, The Surgeon General's Office, in a letter to the Equipment Laboratory, instituted action to modify the original drawings of the adapter so that it could be used with the "Convertible Toboggan Sled" as well as the military toboggan.

The Office of the Quartermaster General advises that 3,000 of the Sled, Toboggan, Convertible have been procured. If your office concurs in a simple change which can be applied to those Adapters, Toboggan, Lit-

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ter now in the field as well as those being procured, it is requested that the necessary action be taken to make this change in the drawings and a revised copy of such drawings be sent this office.⁷⁴

The simple change, as the Equipment Laboratory soon discovered, was much more complex than had been imagined. The standard litter could not be placed on the Sled, Toboggan, Convertible unless bulk-head, steering handles, and front steering pole were removed.

It was first believed that the bulk-head could be notched to let the rear litter handles pass, but if we do, we would have to build the adapter up so that the front handles would clear the top of the curved front end of the Sled, Toboggan.

The litter handles will not clear either bulk-head or front curve, as they are not wide enough apart to clear 20 inches, being about $18\frac{1}{2}$ inches between their inner edges; and bulk-head and front curve are 20 inches wide. If we set the litter forward, it will necessitate raising it so that the front handles will clear the top of the sled ambulance. Even if we do not use bulk-head and steering handles, the litter will have to be set back so the front handles clear, leaving the litter extended back so as to preclude the use of the brake.

If it is desired to use the litter on this sled, toboggan, it will be necessary to remove the rear steering handles and raise the litter to a height of 10 inches on adapters, or else remove both rear steering handles and bulk-head and set litter back so front handles will clear front curve.

It is the opinion of this office that neither of these would be satisfactory.

In view of the above, information is requested as to whether it is desired for us to try and modify the adapter or not, and whether to raise the litter to clear front or to remove bulk-head and set litter back.⁷⁵

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After studying the above analysis of the problems involved in the adaptation of the standard litter to the toboggan sled, The Surgeon General's Office replied with the following constructive recommendation:

In view of the fact that it is desired, if possible, to use the Adapter, Toboggan, Litter, with the Sled, Toboggan, Convertible, it is suggested that if the handles, bulk-head and front steering pole were removed, then by making a minor change in the Adapter, Toboggan, Litter, such as drilling additional holes, it can then be used for both the Sled, Toboggan, Convertible and the standard Toboggan.

This change will probably interfere with the use of the brake and it is recommended that in order to provide brake action in descending hills, a very efficient method can be provided by dropping a heavy rope or chain attached to both sides of the sled over the front of the sled and allow it to drag under the runners.

It is requested that your office study these remarks carefully and see if this is feasible. If your office concurs, it is requested that necessary changes be made in drawing of Adapter, Toboggan, Litter.⁷⁶

These suggestions apparently opened the way for a practical solution of the problem for, on 31 May 1944, the Equipment Laboratory forwarded revisions of previous tentative specifications and drawings for the toboggan litter adapter, and announced that interchangeability had been effected between the adapter and both the military toboggan and the convertible toboggan sled.⁷⁷ The new specification changes were duly coordinated with the Army Medical Purchasing Office in New York City,⁷⁸ and, by 15 July 1944, the modification proceedings had been completed.⁷⁹

IV. Conclusion.

A. Project Termination.

As we have seen, there was now virtually unanimous agreement that Development Project, F-29, be

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discontinued. There remained merely the formal processing of the recommendation. On 18 July 1944, the Subcommittee of the Medical Department Technical Committee, citing the original test report and findings of the Mountain and Winter Warfare Board and the concurrences filed by Army Ground Forces, Army Service Forces, The Surgeon General's Office, and the Medical Department Equipment Laboratory, recommended that the subject project be discontinued for the reasons set forth in the aforementioned references.⁸⁰

On 24 July 1944, this Subcommittee report was approved without modification by the Medical Department Technical Committee,⁸¹ and three days later The Surgeon General's Office sent a formal communication to Headquarters, Army Service Forces, requesting that cancellation of the development project on the snow and ice ambulance be approved.⁸² Army Service Forces approval of the discontinuance request was granted on 30 July 1944,⁸³ and by 8 August 1944 the Equipment Laboratory at Carlisle Barracks, Pennsylvania as well as all interested agencies within The Surgeon General's Office had been notified of the Army Service Forces action and directed to take immediate steps to terminate all project activities.⁸⁴

B. Evaluation of Development Project, F-29.

1. The Adapter, Toboggan, Litter.

The standardization of a toboggan litter adapter, designed to accommodate the standard Medical Department litter to the Quartermaster military toboggan, and the subsequent modification of this item to make possible its use with the convertible toboggan sled as well as the military toboggan, were the only tangible accomplishments of Development Project, F-29. The toboggan adapter had not, however, been included among the original objectives of the project and, so far as documentary evidence is concerned, it is difficult to discover under what specific authority the actual developmental work was performed. As to an evaluation of the adapter itself, insufficient data is at present available to warrant a definite conclusion. Only a limited number of the new adapters were procured during the war,⁸⁵ and as yet Annual Reports submitted by medical installations in the field to The Surgeon General's Office contain little or no first hand information regarding the serviceability of the item in actual field operations. That the development work was accomplished very expeditiously, and that standard-

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ization proceedings were completed in a remarkably short time has already been noted. In this respect particularly, the history of the toboggan adapter stands out in highly favorable contrast to that of the ski litter adapter which was discussed in the preceding chapter.

2. The Snow and Ice Ambulance.

The evaluation of Development Project, F-29, with respect to its one professed objective--that of developing a satisfactory snow and ice ambulance for use in over-the-snow evacuation--can be drawn directly from the final test report of the Mountain and Winter Warfare Board. It was found by the Board that the two-runner and four-runner ambulances designed by the Equipment Laboratory, while light enough to be hand towed for a few yards, were too light and insubstantial to withstand the rigors of intensive operations in the field. Conversely, it was found that the Allis Chalmers M19 Snow Trailer, while sufficiently sturdy to stand up under rough field usage, was much too heavy to be hand towed. On the basis of these findings, the Board concluded that it was impossible to produce the type of vehicle envisioned in the military characteristics established for the subject project.

The facts developed thus far constituted in no sense an indictment of Medical Department research and development personnel. That research and development projects, however carefully and competently conducted, do not invariably yield concrete and practical end-products is a truism applicable to all types of scientific experimentation. However, the Mountain and Winter Warfare Board advanced one further conclusion that did amount to a criticism of the Medical Department. It was asserted by the Board that there was no military requirement for a snow and ice ambulance of the trailer type for use in mountain evacuation. It was stated that by rigging the M29 Cargo Carrier to accommodate litter patients, and by using the regulation cargo sled as a supplementary item, all needs for vehicular evacuation between collecting and clearing stations would be met. This view, it may be noted, was concurred in by Army Ground Forces and Headquarters, Army Service Forces.

Why, then, were the possibilities of the M29 and the Cargo Sled not discovered at the outset instead of at the termination of development activity? Why, moreover, in conforming to the procedural requirements incident to project initiation, was this omission not detected by the headquarters offices of

Army Service Forces or Army Ground Forces or by the Ordnance representative on the Medical Department Technical Committee?

The latter inquiry is beyond the scope of this paper to investigate. Insofar as Medical Department responsibilities were concerned, it would appear that the preliminary investigations undertaken by the Equipment Laboratory and The Surgeon General's Office were inadequate. While a new OSRD "Weasel" had been examined in January, 1943, by The Surgeon General's Office, and found to be too small and too roughriding to be used for over-the-snow evacuation, there is no written indication that other larger types of full-track vehicles were studied with equal care. Similarly, while the Equipment Laboratory requested copies of all specifications and drawings of Quartermaster toboggans, no request appears to have been made for a complete listing of Ordnance vehicles which might conceivably have been rigged to accommodate litter wounded.

3. The Finnish Akja (Snowboat).

From 15 February 1945 to 8 April 1945, extensive cold weather maneuvers were conducted by elements of the Canadian Army for the specific purpose of testing a wide variety of winter equipment. At the conclusion of these maneuvers, known as "Exercise, Polar Bear", an official Observers Report was prepared by a commission composed of three officers of the Royal Canadian Army and two Majors, Medical Corps, representing the United States Army. Conceding the value of the M29 Cargo Carrier in over-the-snow evacuation, the commission went on to observe that an even more effective transportation device was the Finnish Snowboat or Akja.

The best all-around means of transportation of ~~transportation of~~ wounded used on Polar Bear Exercises was the Snowboat or Akja. It had the following advantages over other means:

- a. Travelled well in the deepest snow that could be negotiated by men on snowshoes. Sleds and litters on skis bogged down in loose snow more than 12" deep.
- b. Does not snag on brush, wind-falls and rocks blocking the trail. Many sleds and skis were broken in this manner.

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- c. May be floated across small streams.
- d. Provides more all-round protection for the casualty against wind, protruding brush, etc.
- e. Can be carried by four men around or over obstacles as easily as a litter.
- f. Much lighter in weight than sleds and its shorter length makes maneuvering around turns on tortuous trails easier.
- g. Can be used as a cargo carrier as well.
- h. Adaptable to roping casualties down cliffs, over ravines, etc.

Its disadvantages were:

- a. The model supplied for the exercise was constructed of heavy wood which was not particularly durable since it had no resilience. This could be corrected by construction of plywood.
- b. The akja does not travel as well over established, well-packed and practically straight trails as the sled. Sleds should be included in the equipment for use in such places, but are not absolutely necessary.⁸⁶

The snowboat had also been tested during the winter of 1944 by American Army troops. In maneuvers held in the vicinity of Camp McCoy, Wisconsin, the 76th Division had made extensive use of snowboats and had found them to possess many unique advantages. Recommendations were made at that time to substitute plywood for hardwood construction and to make other minor alterations in design so that the item could be more widely used.⁸⁷

The Finnish Akja appears to have possessed all of the military characteristics which were established for Development Project, F-29. Moreover it was preferred by a mixed military commission to the M29 Cargo Carrier for the transportation of wounded over snow and ice-covered terrain. It does not appear, however, that this item was considered by research

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authorities during the course of the subject project. This apparent omission, along with the previously mentioned oversight in connection with the M29 Cargo Carrier, would seem to indicate that shortening to a minimum the period of initial exploratory investigation had, in the present instance, involved more loss than gain.

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FOOTNOTES TO CHAPTER IV, SECTION 2

- ¹ Ltr. to CG, Alaskan Defense Command, fr. Office of Experimental Board, Alaskan Defense Command, 18 Mar. 1941; subject: "Test of Sled and Toboggan for Transportation of Wounded," Test Directive No. 31 (Rec. Rm., S.G.O. 451.9-1).
- ² Ibid.
- ³ Cited in ltr. to S.G.O., fr. CO, 87th Inf. Mt., Camp Hale, Colo., 17 Mar. 1942; subject: "Snow Sled (Folding)" (Rec. Rm., S.G.O. 451.9-1).
- ⁴ Ltr. to Snocraft, Ind., Norway; Maine, fr. Lt. Col. O.S. Rolfe, 87th Inf. Mountain Div., Camp Hale, Colo., 17 Feb. 1942 (Rec. Rm., S.G.O. 451.9-1).
- ⁵ See n. 3.
- ⁶ Memo. to Medical Intelligence Br., Preventive Medicine Div., S.G.O., fr. Planning Div., S.G.O., 1 Jan. 1943; subject: "Report on Weasel Type Tractor" (A.M.R. & D. Bd.).
- ⁷ Ltr. to S.G.O., fr. Quartermaster Corps, 3 Feb. 1943; subject: "Rescue Toboggan" (M.D.E.L.).
- ⁸ 2d Ind. to S.G.O., fr. M.D.E.L., 8 Mar. 1943; basic: see n. 7 (M.D.E.L.).
- ⁹ Ibid.
- ¹⁰ Ltr. to M.D.E.L., A.G.F. and J.A.G.D., fr. S.G.O., 19 Feb. 1943; subject: "Cold Weather Operations and Application of Medical Equipment to Such Operations" (A.M.R. & D. Bd.).
- ¹¹ Mss. Problems of Evacuation - Snow and Ice, 18 Feb. 1943 (A.M.R. & D. Bd.).
Mss. Problems of Evacuation - Light Alpine Division, 19 Feb. 1943 (A.M.R. & D. Bd.).
- ¹² Ltr. to S.G.O., fr. M.D.E.L., 27 Feb. 1943; subject: "Recommendation for new Project" (Rec. Rm., S.G.O. 451.9-1 Carlisle Bks.-N).

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- 13 1st Ind. to M.D.E.L., fr. S.G.O., 3 Mar. 1943; basic: see n. 12 (Rec. Rm., S.G.O. 451.9-1 Carlisle Bks.-N).
- 14 Ltr. to S.G.O., fr. M.D.E.L., 8 Mar. 1943; subject: "Additional Research Projects for Fiscal Year 1943" (A.M.R. & D. Bd.).
- 15 Ibid.
- 16 Ltr. to Plans Div., S.G.O., fr. Research & Development Div., S.G.O., 13 Mar. 1943; subject: "Snow and Ice Ambulance - Project F-29" (A.M.R. & D. Bd.).
- 17 1st Ind. to M.D.E.L., fr. S.G.O., 19 Mar. 1943; basic: see n. 14 (A.M.R. & D. Bd.).
- 18 Ltr. to M.D.T.C., fr. Subcommittee, M.D.T.C., 14 Apr. 1943; subject: "Snow and Ice Ambulance" (A.M.R. & D. Bd.).
- 19 Report of the Medical Department Technical Committee, 10 May 1943; subject: "Snow and Ice Ambulance" (A.M.R. & D. Bd.).
- 20 Ltr. to CG, A.S.F., fr. S.G.O., 13 May 1943; subject: "Snow and Ice Ambulance" (A.M.R. & D. Bd.).
- 21 1st Ind. to S.G.O., fr. Requirements Div., A.S.F., 20 May 1943; basic: see n. 20 (A.M.R. & D. Bd.).
- 22 Memo. to Chf., Supply Service, Dir., Fiscal Div., Chf., Field Equipment Br., Plans Div., fr. Dir., Research Coordination Br., S.G.O., 10 Jun. 1943; subject: "Snow and Ice Ambulance" (A.M.R. & D. Bd.).
- 23 Supra., p. 226.
- 24 Ltr. to Q.M.G., fr. M.D.E.L., 20 Mar. 1943, subject: "Toboggans, Sleds, and Skis" (M.D.E.L.).
- 25 Ltr. to M.D.E.L., fr. O.Q.M.G., 27 Mar. 1943; subject: "Procurement of Skis and Toboggans" (M.D.E.L.).
- 26 Ltr. to S.G.O., fr. M.D.E.L., 30 Mar. 1943; subject: "Procurement of Skis and Toboggans" (M.D.E.L.).

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- 27 Monthly Narrative Report, M.D.E.L., 1 Mar. to 31 Mar. 1943
(A.M.R. & D. Bd.).
- 28 Monthly Narrative Report, M.D.E.L., 1 Apr. to 30 Apr. 1943
(A.M.R. & D. Bd.).
- 29 Memo. to M.D.E.L., fr. S.G.O., 22 Apr. 1943, CONFIDENTIAL
(A.M.R. & D. Bd.). Extracted in clear.
- 30 Monthly Narrative Report, M.D.E.L., 1 May to 31 May 1943
(A.M.R. & D. Bd.).
- 31 Office memo., M.D.E.L., 12 Jun. 1943; subject: "Snow and
Ice Ambulance" (A.M.R. & D. Bd.).
- 32 Monthly Narrative Report, M.D.E.L., 1 Jun. to 30 Jun. 1943
(A.M.R. & D. Bd.).
- 33 Ibid.
- 34 Monthly Progress Report, S.G.O., 15 Apr. 1943, SECRET (Hist.
Div., S.G.O.). Extracted in clear.
- 35 The following illustrations were drawn from correspondence
between the Equipment Laboratory and the Jerald Sulky Co.,
extending from 19 Jun. to 5 Oct. 1943 (M.D.E.L.).
- 36 Ltr. to Jerald Sulky Co., Waterloo, Ia., fr. Dir., M.D.E.L.,
6 Jul. 1943 (M.D.E.L.).
- 37 Ltr. to M.D.E.L., fr. Jerald Sulky Co., Waterloo, Ia., 3
Jul. 1943 (M.D.E.L.).
- 38 Ltr. to Jerald Sulky Co., Waterloo, Ia., fr. M.D.E.L.,
6 Jul. 1943 (M.D.E.L.).
- 39 Ltr. to M.D.E.L., fr. Jerald Sulky Co., Waterloo, Ia., 20
Jul. 1943 (M.D.E.L.).
- 40 Ltr. to M.D.E.L., fr. Jerald Sulky Co., Waterloo, Ia., 26
Aug. 1943, and notation thereon (M.D.E.L.).
Monthly Narrative Report, M.D.E.L., 1 Aug. to 31 Aug. 1943
(A.M.R. & D. Bd.).

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- 41 Monthly Progress Report, S.G.O., 13 Aug. 1943, SECRET (Hist. Div., S.G.O.). Extracted in clear.
- 42 Monthly Narrative Report, M.D.E.L., 1 Oct. to 31 Oct. 1943 (A.M.R. & D. Bd.).
- 43 Memo. to Jerald Sulky Co., Waterloo, Ia., fr. Dir., M.D.E.L., 12 Oct. 1943 (M.D.E.L.).
- 44 Ltr. to S.G.O., fr. M.D.E.L., 23 Oct. 1943; subject: "Adapter, Toboggan Litter" (A.M.R. & D. Bd.).
- 45 1st Ind. to CG, A.G.F., fr. S.G.O., 1 Nov. 1943; basic: see n. 44 (A.M.R. & D. Bd.).
- 46 2d Ind. to CG, A.S.F., fr. Army War College, A.G.F., 13 Dec. 1943; basic: see n. 44 (A.M.R. & D. Bd.).
- 47 Memo. to Chairman, M.D.T.C., fr. Plans Div., S.G.O., 16 Dec. 1943; subject: "Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).
- 48 Memo. to Chairman, M.D.T.C., fr. Plans Div., S.G.O., 21 Dec. 1943; subject: "Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).
- 49 Medical Department Technical Subcommittee Report: Adapter, Toboggan, Litter, 21 Dec. 1943 (A.M.R. & D. Bd.).
- 50 Ltr. to Hist. Div., S.G.O., fr. A.M.P.O., 26 Jul. 1945 (Hist. Div., S.G.O.).
- 51 Min. of M.D.T.C., 19 Jan. 1944, RESTRICTED (Hist. Div., S.G.O.). Extracted in clear.
- 52 Incl. 2 to ltr. to CG, A.S.F., fr. S.G.O., 20 Jan. 1944; subject: "Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).
- 53 2d Ind. to S.G.O., fr. Hq., A.S.F., 29 Jan. 1944; basic: see N. 52, above (A.M.R. & D. Bd.).
- 54 Memo. to Chf., Supply Service, S.G.O., Chf., Field Equipment Development Br., Plans Div., S.G.O., Dir., Procurement Liaison Br., A.M.P.O., Chf., Organization and Equipment Allowance Br., Plans Div., S.G.O., fr. Plans Div., S.G.O.,

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31 Jan. 1944; subject: "Adapter, Toboggan, Litter"
(A.M.R. & D. Bd.).

⁵⁵ See n. 50.

⁵⁶ Monthly Status Report, S.G.O., SECRET, 15 Jan. 1944 (Hist. Div., S.G.O.). Extracted in clear.

⁵⁷ Ltr. to M.D.E.L., fr. Jerald Sulky Co., Waterloo, Ia.,
19 Nov. 1943 (M.D.E.L.).

⁵⁸ Ltr. to S.G.O., fr. M.D.E.L., 25 Nov. 1943; subject: "Snow
and Ice Ambulance" (M.D.E.L.).

⁵⁹ 3rd Ind. to CG, A.S.F., fr. Army War College, A.G.F., 20
Nov. 1943; basic: see n. 58 (A.M.R. & D. Bd.).

⁶⁰ Incl. (Test Sheet Data) to 6th Ind. to S.G.O., fr. M.D.E.L.,
29 Dec. 1943; basic: see n. 58 (A.M.R. & D. Bd.).

⁶¹ Memo. to CG, A.S.F., fr. S.G.O., 18 Jan. 1944; subject:
"Snow and Ice Ambulance" (A.M.R. & D. Bd.).

⁶² Ltr. to Pres., Mountain & Winter Warfare Bd., Camp Hale,
Colo., fr. Army War College, A.G.F., 5 Feb. 1944; subject:
"Test of Snow and Ice Ambulance" RESTRICTED (A.M.R. & D.
Bd.). Extracted in clear.

⁶³ 1st Ind. to Chf., Ground Requirements Sec., A.G.F., Army War
College, fr. Mountain & Winter Warfare Bd., Camp Hale, Colo.,
3 May 1944, RESTRICTED; basic: see n. 62 (A.M.R. & D. Bd.).
Extracted in clear.

⁶⁴ Report of Test of Snow and Ice Ambulances, The Mountain and
Winter Warfare Board, Camp Hale, Colo., 2 May 1944, Test No.
40, Directive MW-M-6-B, RESTRICTED (A.M.R. & D. Bd.).
Extracted in clear. The testing data which is discussed in
the succeeding pages is all drawn from the subject report.

⁶⁵ See n. 64.

⁶⁶ Ibid., p. 9.

⁶⁷ Ibid., p. 11.

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68 Ibid., p. 10.

69 See n. 63.

70 2d Ind. to CG, A.S.F.; (Attn: Dir., Research & Development Div.), 20 May 1944; basic: see n. 62 (A.M.R. & D. Bd.).

71 3rd Ind. to S.G.O., fr. Hq., A.S.F., 22 May 1944; basic: see n. 62 (A.M.R. & D. Bd.).

72 4th Ind. to M.D.E.L., fr. S.G.O., 30 May 1944; basic: see n. 62 (A.M.R. & D. Bd.).

73 5th Ind. to S.G.O., fr. M.D.E.L., 5 Jun. 1944; basic: see n. 62 (A.M.R. & D. Bd.).

74 Ltr. to M.D.E.L., fr. S.G.O., 5 May 1944; subject: "Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).

75 1st Ind. to S.G.O., fr. M.D.E.L., 9 May 1944; basic: see n. 74 (A.M.R. & D. Bd.).

76 2d Ind. to M.D.E.L., fr. S.G.O., 22 May 1944; basic: see n. 74 (A.M.R. & D. Bd.).

77 Ltr. to S.G.O., fr. M.D.E.L., 31 May 1944; subject: "Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).

78 Ltr. to S.G.O., fr. A.M.P.O., 12 Jul. 1944 (A.M.R. & D. Bd.).

79 Ltr. to Development Br., Technical Div., S.G.O., fr. Chf., Supply Coordination Br., Technical Div., S.G.O., 15 Jul. 1944; subject: "Medical Department Tentative Specifications No. 1700-A f/Adapter, Toboggan, Litter" (A.M.R. & D. Bd.).

80 Ltr. to M.D.T.C., fr. Med. Dept. Tech. Subcomm., 18 Jul. 1944; subject: "Ambulance, Snow and Ice (F-29)" (A.M.R. & D. Bd.).

81 Concurrence Sheet, 24 Jul. 1944; subject: "Ambulance, Snow and Ice (F-29)", signed by Secy., M.D.T.C. (A.M.R. & D. Bd.).

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- 82 Ltr. to CG, A.S.F., fr. S.G.O., 27 Jul. 1944; subject: "Ambulance, Snow and Ice (F-29)" (A.M.R. & D. Bd.).
- 83 1st Ind. to S.G.O., fr. Hq., A.S.F., 30 Jul. 1944; basic: see n. 82 (A.M.R. & D. Bd.).
- 84 Memo. to M.D.E.L., fr. S.G.O., 8 Aug. 1944; subject: "Snow and Ice Ambulance" (A.M.R. & D. Bd.). See also - Memo. to Chf., Development Br., S.G.O., fr. Chf., Research Coordination Br., S.G.O., 5 Aug. 1944; subject: "Ambulance, Snow and Ice (F-29)" (A.M.R. & D. Bd.).
- 85 Ltr. to Hist. Div., S.G.O., fr. A.M.P.O., 26 Jul. 1945 (Hist. Div., S.G.O.).
- 86 Observers Report on Exercise "Polar Bear," Canadian Army "Wet Cold" Exercise, 15 Feb. to 8 Apr. 1945, submitted by Thomas W. Deakin, Maj., M.C., U.S.A., 8 Jun. 1945, SECRET (Training Div., S.G.O.). Extracted in clear.
- 87 Winter Training Report, 76th Div., Camp McCoy, Wis., 25 Mar. 1944 (Hist. Div., S.G.O.).

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CHAPTER IV

MISCELLANEOUS LITTERS AND LITTER ADAPTERS

Section 3

Development Project, F-30

Litter Stop Attachment for Amphibian Truck

I. Introduction.

A. Shore-to-Ship Evacuation.

Because of the extent and magnitude of joint amphibious operations in World War II, the development of new or improved techniques of shore-to-ship evacuation of casualties was a matter of genuine concern to both the Army and Navy medical services. The project history which follows furnishes a good illustration of the way in which various agencies--in this case the Medical Department, the Office of Scientific Research and Development, Ordnance Department, the Engineer Amphibian Command, and private industry--cooperated to increase the efficiency of this particular phase of over-sea operations.

In beginning this discussion it should be pointed out that the basic plan of over-the-water evacuation employed by American forces during World War II was not something which had been suddenly and hastily contrived. Although detailed field manual instructions for the conduct of medical service in joint amphibious operations first appeared in March, 1940--just six months after the outbreak of war in Europe--these instructions were in effect a concrete application of the provisions of numerous official agreements which had been built up between the Army and Navy over a long period of time.¹

The coordinated plan of joint medical service was not, in principle, greatly dissimilar from the plan conventionally followed in land warfare. The chain of evacuation through which a casualty passed was essentially the same whether he was being moved from a landing beach to a troop or hospital ship, or from a battalion aid station backward through successive echelons of Army ground installations.

In Medical Field Manual 8-25, "Medical Service in joint Oversea Operations," the close analogy between the two systems of evacuation was illustrated in this fashion:

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Hospital ships at anchorage in the landing area are comparable to evacuation hospitals receiving patients from front-line divisions in normal land operations. Beach heads are comparable to division hospital stations; and the boats plying between shore and hospital ships correspond to the Army ambulance companies in the Army scheme of evacuation.²

The analogy between ground and amphibious evacuation was applicable, moreover, in one other important respect. Both systems had undergone far-reaching changes during World War II as a result of the impact of modern technology. This increased mechanization, involving among other things the introduction of larger and more complex motorized equipment, had stepped up markedly the speed of both land and sea evacuation.

In amphibious operations, for example, casualty evacuation was greatly accelerated by the development and introduction into the medical service of the IST and LCI types of vessel. These large, blunt-prowed craft with their unique ramp equipment could be used not only as cargo and personnel carriers during landing operations, but could be employed with equal effectiveness as naval "ambulances" on their return trips. By virtue of their greater carrying capacity, ease of loading, and transportational safety, the new vessels represented a marked advance over the small launches, motorboats, and miscellaneous craft which had hitherto been employed in shore-to-ship evacuation.³

With the appearance of the amphibian tractor or tank (LVT), the weasel or tracked jeep (M29C), and the amphibian truck or "Duck" (DUKW), even more dramatic possibilities were opened up for the improvement of shore-to-ship evacuation. Through increased use of these vehicles in amphibious warfare, not only was a closer coordination of military and naval combat operations made possible, but it was soon evident that a number of previously necessary manual operations, which were both time-consuming and laborious, might now be eliminated completely from the evacuation process.

The present study describes the ultimately successful attempt that was made to increase the efficiency of over-the-water evacuation procedures by adapting one of the above vehicles--the 2½-ton, amphibian truck--to the demands of both land and sea transportation of wounded.

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B. Initiation of Development Project, F-30.

The formal action which seems to have been mainly responsible for the establishment of a research project to convert the new DUKW into a dual purpose vehicle, capable of functioning as an amphibious ambulance as well as a cargo and personnel carrier, did not, judging from the records, originate with the Medical Department. The earliest evidence found of official intention in this regard is contained in a memorandum, dated 31 March 1943, from The Assistant Chief of Staff, G-4, to the Requirements Division, Headquarters, Army Service Forces. This communication confirmed a telephone conversation between representatives of the above offices in which a request had been made (presumably by the Requirements Division) that The Surgeon General be directed to investigate the possibilities of using the 2½-ton amphibian truck as an ambulance where movement over water was involved.⁴

Upon receipt of this G-4 memorandum, the Director of the Requirements Division addressed the following memorandum to The Surgeon General:

1. It has come to the attention of this Headquarters that the truck, 2½ ton, 6x6, Amphibian may be equipped with some ten (10) litters for the transportation of wounded. It is proposed to use this vehicle as an ambulance between shore installations and hospital ships. It is believed that this method of evacuation would eliminate the need for transfer of the patients from a standard 3/4 ton ambulance at the dock to a small boat and from the small boat to the hospital ship since the subject amphibian could proceed directly to the ship and be raised to the ship's deck by means of the ship's davits without transferring the patients. It is believed that this method of transporting wounded personnel is of sufficient promise to warrant consideration by your office.

2. Your comments and recommendations are desired with reference to the employment of the truck, 2½ ton, 6x6, Amphibian as an ambulance for evacuation of wounded from shore installations direct to hospital ships.⁵ #

It was clear from a reading of the above document that the proposed development, if successful, would result in a substantial reduction in the number of loading and unloading operations hitherto required in over-the-water evacuation. Accordingly, a draft indorsement was promptly prepared by the Research and Development Division of The Surgeon General's Office, requesting that two amphibian trucks be shipped to

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the Medical Department Equipment Laboratory at Carlisle Barracks, Pennsylvania, for the purpose of studying litter arrangements and conducting tests.⁶ This proposed indorsement was then cleared through the Hospital and Evacuation Division which gave its concurrence, merely adding the suggestion that a very thorough shore-to-ship evacuation test should be given to insure that action of small waves would not make the going too rough for badly wounded patients.⁷

Having cleared the Army Service Forces recommendation with the two offices principally concerned, on 10 April 1943 The Surgeon General sent his formal reply to the basic communication. In addition to the request for two amphibian trucks to be used for experimental purposes, it was further recommended that authority be granted the Director of the Equipment Laboratory to arrange with the Engineer Amphibian Command, or other suitable organization, to assist in the conduct of the proposed tests.⁸ The requested authority was soon forthcoming. On 15 April 1943, Headquarters Army Service Forces, replied that the Deputy Chief of Ordnance, Detroit, Michigan, had been directed by separate memorandum to divert two amphibian trucks to the Equipment Laboratory at Carlisle, and stated further that direct communication between the Medical Department and the Engineer Amphibian Command would be permitted in order to expedite completion of the project.⁹ Notification of the above action was sent to the Director of the Equipment Laboratory by The Surgeon General's Office on 22 April 1943.¹⁰ As we shall see, this notice was to have the same effect as the issuance of formal instructions to begin work on the project.¹¹

While a careful examination of the published minutes of all meetings of the Medical Department Technical Committee held during this period does not disclose that this project was ever officially processed by that body, a brief reference to it was made a few months later by the Committee. At a meeting held 28 June 1943, it was read into the record by the Secretary that initiation of a development project to produce an amphibian ambulance had been approved by higher authority on 17 April 1943, and that development of this item had been in progress since the date of approval.¹²

Investigation of the files of Headquarters, Army Service Forces--presumably the higher authority whose approval was cited in the above statement--reveals only one document relating to this subject, bearing the date of 17 April 1943 and addressed to The Surgeon General. That communication, a first indorsement forwarding certain technical data recently received from G-4, reads as follows:

Forwarded for your information in connection
with approved development project on the use of

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the Truck, 2½ ton, 6x6, Amphibian, for water-borne [sic] evacuation of wounded.¹³

If this was the document referred to, it would seem that it fell somewhat short of constituting full compliance with the project approval procedures described in AR 850-25.¹⁴

While, as we have just seen, regularized procedures do not seem to have been followed too closely in the initiation of Development Project, F-30, it should be remembered that a considerable amount of coordination had been accomplished through routine administrative processes. Several interested agencies within The Surgeon General's Office, for example, had actively shared in the task of drafting a reply to the initial project proposal presented by Headquarters, Army Service Forces. Moreover, through ordinary correspondence channels authority was sought and obtained to establish direct liaison between the Medical Department and the Engineer Amphibian Command for the duration of the project.

However, these independent actions, constructive though they were, did not compensate completely for the failure to make use of the procedural facilities of the Medical Department Technical Committee. In the first place, an opportunity had thereby been missed, at a time when project plans were still highly flexible, for direct consultation with representatives of all interested Arms and Services. Secondly, by omission of this particular procedural step, formulation of military characteristics was delayed by several months.¹⁵ While it would be easy to exaggerate the gravity of this latter postponement, it was nevertheless true that prompt preparation of an acceptable statement of military characteristics was officially regarded as an integral part of the project initiation process.¹⁶

II. Development Phase.

A. Preliminary Investigation.

The earliest exploratory studies relating to Development Project, F-30 appear to have been made not by the Equipment Laboratory or other Medical Department instrumentality, but by the National Defense Research Committee of the Office of Scientific Research and Development, Washington, D.C. The Transportation Division (Division 12) of this latter agency, which had played a leading role in the development of the original amphibian truck, had been investigating the possibilities of converting the vehicle into an amphibian ambulance for some time prior to the initiation of this project. There are, in fact, indications--though available

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evidence on this point is not conclusive--that knowledge of the preliminary experimental activities being conducted by Division 12 was an important factor in influencing the Requirements Division (Headquarters, Army Service Forces) to recommend establishment of a Medical Department research project to conduct further work on this problem.¹⁷

In any event, early in April, 1943, studies were going forward at the Amphibian Vehicle Training School, Charleston, South Carolina, under the sponsorship of Division 12 of the National Defense Research Committee, for the specific purpose of adopting the DUKW to meet the demands of bridgehead-to-hospital ship evacuation. By 4 April 1943, moreover, a plan had been worked out at this training center by one Dennis Puleston, subsequently listed as a Technical Aid in Division 12, which not only included a mechanical solution to the problem (litter arrangement, method of fastening litters to coaming, etc.), but also contained a detailed description of a recommended sequence of operations to be followed by aid men in casualty-loading and unloading.

Because of its basic similarity to the solution which was ultimately adopted by the Medical Department, this preliminary plan is quoted here in full:

PROPOSED USE OF DUKWS IN EVACUATION OF CASUALTIES
FROM BRIDGEHEAD TO SHIP'S DECK

This plan will enable twelve standard Army Medical Corps stretchers, each with casualty, to be stowed in one DUKW together with two attendants (exclusive of DUKW driver and assistant driver, both located in cab). It is intended that the casualties, once they are stowed in the DUKW, will not again be handled until after the DUKW has been picked up at ship's side and deposited on deck. After that they can be transferred into the special litters used for conveyance into the sick bay.

The sequence of operations follows:

- a. Stretcher with casualty having been passed up to the two attendants standing in DUKW cargo compartment, it is laid on the floor of the cargo compartment at 45 degrees angle to the fore and aft of the DUKW. It is then swung around until it is at right angles to the fore and aft line of the DUKW and slid all the way forward until one side is against the forward bulkhead of the cargo compartment.

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- b. Second stretcher is handled in similar manner to (a); when it is on floor of cargo compartment, it is slid forward until it is against stretcher (a).
- c. Third, fourth, fifth and sixth stretchers are also laid on floor of cargo compartment, one by one, but they are placed in a fore and aft direction with one of their ends against the after end of the cargo compartment. It will be found that this will leave a space of approximately fifteen inches between the second stretcher and the handles of the third, fourth, fifth and sixth stretchers. This space is used as standing room for the one or two attendants which will accompany the casualties to the ship.
- d. Seventh and eighth stretchers are then passed up and laid at right angles to the fore and aft line of the DUKW, with the handles resting on the coamings on either side of the DUKW. The stretchers are slid all the way forward to the forward end of the cargo compartment. To prevent the stretchers handles from slipping off the coamings (there is an approximate two inch overlap on each side), I would suggest (a) that the stretcher handles be drilled so that small pins could be dropped in to set each side of the coaming, or (b) that a special metal clip be designed to be attached to the stretcher handles and to clip onto the coaming.
- e. Ninth, tenth, eleventh and twelfth stretchers are also laid on the coamings, at the after end of the cargo compartment, so that a fifteen inch space is left between the eighth and ninth stretchers.
- f. If casualties suffering from shock are being handled or there is a prospect of spray coming aboard on the passage to ship's side the tarp bows are set in the bow pockets and the tarpaulin is put up in the usual manner.
- g. When the DUKW reaches ship's side, the four part DUKW sling of $3/4$ " cable is lowered on the cargo boom and the hooks at the ends of the sling are made fast to the DUKW lifting eyes. The DUKW is then hoisted aboard and set on deck, the tarpaulin is removed and

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the casualties taken to the sick bay. The DUKW is loaded with cargo while on deck after which it is lowered overside, to proceed ashore in the usual manner, the two attendants to return to their shore station in the DUKW.¹⁸

The foregoing description, together with a drawing showing schematically how twelve litters could be stowed on board the DUKW, were forwarded to The Assistant Chief of Staff, G-4, on 12 April 1943 by the Office of Scientific Research and Development. One paragraph from this transmittal letter is particularly noteworthy.

You will note that if the Surgeon General is interested in reducing shock by recourse to this method, it would be desirable from our viewpoint and in fact necessary, if we are to meet the engineering requirements of various interested parties, to have a meeting of these parties. To date these would seem to be:

- (a) Your office G-4
- (b) The Surgeon General
- (c) The War Shipping Administration
- (d) The Transportation Corps
 - (1) Arrangements with ship-masters
 - (2) Inclusion in school
- (e) Amphibious Force of the Atlantic Fleet
- (f) National Defense Research Committee
 - (1) Sparkman and Stephens Naval architects
 - (2) General Motors Yellow Truck and Coach¹⁹

Apparently, judging from the above, the Office of Scientific Research and Development expected to take an active part in future research and development work in this field. This, however, was not to be the case. On 14 April 1943, the above communication had its inclosures were forwarded without comment from G-4 to Headquarters, Army Service Forces,²⁰ and three days later the entire file was passed on to The Surgeon General with the brief notation: "Forwarded for your information in connection with approved development project."²¹ By the time this correspondence had reached the Equipment Laboratory,²² it was clear that the Medical Department was to have exclusive control over project management.

It may be observed parenthetically that, while the Puleston plan for conversion of the amphibian truck to a

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temporary ambulance was subsequently given careful consideration, the plan for immediate ~~inter~~-agency coordination proposed by the Office of Scientific Research and Development was not adopted. The General Motors Corporation, one of whose subsidiaries appeared on the above list of "interested parties" with whom consultation was recommended, was not so consulted until nearly seven months later. As it happened, the particular amphibian litter stop which ultimately received official approval, was based on a modified design submitted by this corporation.

B. Development and Testing.

On 24 April 1943, the two amphibian trucks which had been requested from Ordnance Department arrived at the Medical Department Equipment Laboratory at Carlisle Barracks, Pennsylvania.²³ As a first step, the vehicles were loaded according to the Iuleston plan with twelve litter patients and tested, without litter attachments of any kind, for both cross country and amphibious evacuation. These preliminary tests showed that some device was needed to prevent the top litters from shifting or falling through to the truck floor when the amphibian was travelling in surf or heavy seas.²⁴

Several methods of securing the litters were then tried: tying with ropes, individual attachments, and manifold attachments. The best method of securing the litters on the cargo floor, insofar as simplicity, speed, and stability were concerned, was found to be the tying of these stretchers by ropes. It was felt, however, that this would be necessary only when rough roads or heavy surf were encountered. (On such occasions, the use of a light rope to prevent slipping and shifting would be sufficient.)²⁵

As for the securing of the upper tier litters, brief consideration was given to certain individual attachments.²⁶ One such plan had been suggested by Dennis Iuleston in his April communication. His idea had been either to drill holes in the stretcher handles so that pins could be dropped through to the coaming, or to design special metal clips to be attached to each handle and then clipped onto the coaming.

The objections to the first method can be readily anticipated by those who have read the preceding chapters of this study. Because of the practice of "property exchange" in evacuation procedure, a high degree of interchangeability of litter parts was at all times necessary. This meant, in short, that changes in the construction of any one component of a given group of litters (in this case litter handles), would have to be duplicated for virtually every litter in field use. With hundreds of thousands of Army litters already issued, and with a similar number in various stages—

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of procurement and production, the addition now of a specification calling for the drilling of holes in litter handles and for the issuance of special securing pins was obviously impracticable.

The alternative Puleston suggestion--the provision of special metal clips for each litter handle--was somewhat more feasible, but was nevertheless rejected. If twelve litters were to be accommodated in each amphibian vehicle, forty-eight clips would be needed to secure all the litters; twenty-four clips, if only the top tier litters were affected. In either case, the possibilities of loss of these small items in the repeated changeover of the DUKW from an evacuation to a cargo or personnel carrier was extremely high. Moreover, the field issuance and adequate distribution of these small items would be an almost endlessly complicating task for supply officers at the various echelons.²⁷

For these reasons, among others, the Equipment Laboratory concentrated its attention mainly on the "manifold" type of attachment. Within a short time a sectional litter stop had been designed which fastened to the coaming along each side of the amphibian truck, thus preventing the litters on the coaming from sliding across the vehicle and dropping into the cargo space below. In a heavy sea or on rough terrain, the employment of a light rope as a supplementary litter securing device was recommended. This rope was to be wound around the handles of those litters which, because of the spacing of uprights forming the cover-frame of the truck, might shift longitudinally on the coaming.²⁸

As soon as the required number of new litter stops had been constructed, preliminary tests of the two DUKW's equipped with these attachments were made by Equipment Laboratory officials on a lake in the vicinity of Carlisle Barracks.²⁹ The test results appear to have been satisfactory, for only one change of consequence was made thereafter. The Puleston loading plan called for a complete payload of twelve litters. This number was now reduced to ten to permit more space for attendants, and the loading procedure originally outlined by Puleston was altered accordingly to conform to this change.³⁰

Since the tests at Carlisle had been too summary in nature to be considered final, arrangements were made in the latter part of May, 1943, to have the Engineer Amphibian Command at Camp Edwards, Massachusetts, test the two experimental DUKW ambulances in actual shore-to-ship operations.³¹ The trucks were shipped to the new testing point before the close of the month, and on 2 June 1943 a representative of the Equipment Laboratory was present at Camp Edwards to observe and assist in litter loadings and other test operations.

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During this period, however, facilities for shore-to-ship evacuation tests were not available, so it was decided that further testing activities would be continued by the Engineer Amphibian Command alone.³²

But one serious technical problem had already emerged. In attempting to install the litter stop attachments on various amphibian trucks then on hand at Camp Edwards, it was found that they would not fit, due to a difference in construction of the coaming of these trucks as compared with the coaming of the two vehicles which had been employed in the initial development work at Carlisle Barracks.³³ The fact that this discovery had been made at a relatively early stage in the project was, of course, fortunate. We have seen in the previous section on the Ski Litter the difficulties that were encountered when the Mountain and Winter Warfare Board at Camp Hale submitted for standardization a ski adapter which had been designed without prior study of the drawings and blueprints of all existing Medical Department litters.³⁴

Consequently, while the Equipment Laboratory had apparently made a similar error by failing to consider at the outset all existing variations of the item to which its new development was to be adapted, in the present instance immediate steps were taken to remedy this initial oversight. Request was promptly made of the Tank Automotive Center, Ordnance Department, Detroit, Michigan, that blueprints be furnished the Equipment Laboratory on all types of DUKW cargo bodies already manufactured or in process of manufacture.³⁵ Unfortunately this request was destined to have a rather prolonged history. As we shall see, the redesign of the amphibian litter stop was to be held up for more than two months because of the difficulty in obtaining these necessary blueprints.

One further question concerning the adaptability of the Carlisle-designed litter stop was raised during this period. Early in June, the British Joint Staff Mission made inquiries through the Chief of the United States Military Intelligence Service regarding the experimentation currently going forward at the Medical Department Equipment Laboratory in fitting out the DUKW with litter attachments. It was explained that the Combined Operations Command in London was about to attempt a similar conversion of this amphibious vehicle.³⁶

One of the results of this inquiry was to turn the attention of the Equipment Laboratory to the question of the adaptability of its newly devised litter stop to the British type of litter. On 9 June 1943, in a letter to the Engineer Amphibian Command at Camp Edwards, the Director of the Equipment Laboratory expressed his conclusions on this matter as

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follows:

. . . The British Litter is longer than ours, and I believe that difficulty would be experienced in placing it on the cargo floor in the cross position; it would also interfere with the litter stop boards. I have made calculations to see if the stop boards could be extended to accommodate the British Litter, but to do this would sacrifice most of the effectiveness in holding our litters. The boards could be kept at the present dimensions to hold our litter and if the British Litters were used, the handles being longer, could be secured with pieces of rope.³⁷

With the problem of accommodating the British litter thus disposed of, and while still awaiting truck blueprints from the Tank Automotive Center, the Equipment Laboratory received early in July a final test report from Camp Edwards on the amphibian litter stops which had been shipped in June to that command. According to this report, the Medical Battalion of the 4th Engineer Special Brigade had used these attachments in loading tests, transportation of medical supplies, and in the transfer of wounded from the amphibian truck to landing craft in open water. Generally speaking, the results had been quite satisfactory.³⁸

The loading plan which had been submitted by the Equipment Laboratory was found to be entirely practicable, and no change was suggested.³⁹ It should be noted in this connection that early in June the Laboratory had amended its loading plan a second time. Instead of limiting the maximum load to ten litters, five on the coaming and five in the hold (the arrangement adopted in May in preference to the Puleston 12-litter plan) it was decided subsequently that a sixth litter would be so easy to place on the coaming that the surplus space should not be wasted.⁴⁰ It was, therefore, this latest 11-litter plan to which the Engineer Amphibian Command referred in the present instance.

The test report went on to state that eleven simulated casualties had been easily and comfortably transported, even in the roughest water. The tarpaulin regularly supplied with the DUKW had, it was pointed out, offered good protection and, properly arranged, could be readily thrown off in case of accident or if there was danger of the amphibian sinking at sea.⁴¹

While no large freight or passenger ships had been available for shore-to-ship evacuation tests, simulated casualties had been transferred by hand from the amphibian truck to LCT and LCM types of landing craft. No difficulties

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were encountered during these operations, the litter guards or side bars supplied by the Equipment Laboratory holding up well in all instances. It was, however, recommended that, in view of the rougher usage which could be expected in actual combat evacuation, the litter stops should be of somewhat stronger construction. Aside from this suggested change and the recommendation that the attachment be redesigned to fit all types of DUKW coamings, the Engineering Amphibian Command expressed no further objection to adoption of the new device.⁴²

The suggestion that a somewhat more rugged litter stop be constructed, following the same basic design as that of the models just tested, does not appear to have been favorably considered by the Equipment Laboratory, Specifications, insofar as strength characteristics were concerned, underwent no immediate modification. However, as for the other recommendation made by the Engineering Amphibian Command--that the litter be redesigned to fit all types of amphibian truck coamings--the Laboratory had already taken the initial step by requesting blueprints from the Tank Automotive Center showing all structural variations in DUKW design.⁴³ No reply having as yet been received from that quarter, the Equipment Laboratory now turned to the Engineering Amphibian Command itself for this information:

1. Reference is made to Paragraph 4 of basic communication referring to litter guards. This Laboratory has attempted to obtain plans of the different types of coaming on the amphibian trucks but have been unsuccessful to date.

2. It is requested that sketches of the various type of coaming on the amphibians in your command be forwarded to this Laboratory to facilitate work on the litter guard.⁴⁴

A short time later, the following brief reply was received from the Engineering Amphibian Command

Regret to inform you that the information requested in 1st Indorsement is unobtainable.⁴⁵

That this amount of difficulty would be encountered in attempting to obtain a set of standard blueprints was unexpected to say the least. Unfortunately, moreover, the reply which was soon after received from the Ordnance Department likewise failed to settle the matter.

On 21 July 1943--in reply to the Equipment Laboratory's original request of 17 June 1943--the Engineering

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Branch of the Tank Automotive Center in Detroit, Michigan, forwarded a series of fifteen blueprints.⁴⁶ Upon examination, however, Laboratory officials discovered that none of the drawings which had been inclosed covered the Amphibian Truck--the vehicle upon which information had been requested--but instead covered various other truck bodies.

Accordingly, on 5 August 1943, the Equipment Laboratory sent a second request to the Tank Automotive Center:

1. The Equipment Laboratory is in receipt of a number of drawings covering various truck bodies, received from your office. The details of the truck this office is particularly interested in and which was not included is the Amphibian Truck, DUKW, 2½ ton, GMC.

2. A litter stop, to hold litters across the cargo space of the Amphibian truck, which was designed by this Laboratory will fit the upper edge or cowl of the cargo body on some of the Amphibian Trucks but will not fit others as the cowls vary in construction. It has been found that the construction of the sides near the cargo floor also vary in construction details. It is requested that drawings of the above mentioned features of the various designs of the Amphibian trucks be forwarded this Laboratory in order that we may continue our work on these vehicles.⁴⁷

The above letter produced results. On 26 August 1943, the requested data was forwarded by the Tank Automotive Center to the Equipment Laboratory.⁴⁸

On 20 September 1943, approximately five months after initiation of Development Project, F-30, a statement of approved military characteristics for the new amphibian litter stop was received by the Equipment Laboratory.⁴⁹ With all relevant data now at hand (although it is apparent that the list of military characteristics had arrived too late to be of directional value), the Laboratory was at last in a position to give full attention to its re-designing task. That task now proved to be a great deal more complex than had originally been anticipated.

Study of the blueprints lately received from the Tank Automotive Center revealed that, in order to be adaptable to all 2½-ton amphibian trucks currently being used by the Army, the new litter stop would have to be re-designed to fit three different types of coaming. Type I, which was the earliest of the coaming designs and was radically

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different from those subsequently adopted, had been used in the construction of 281 vehicles. Type II, a combination unit, had been used on the next 724 vehicles. Type III, the coaming for which the first litter stops had been expressly made, had been used on all succeeding vehicles, after the first 1,005.⁵⁰

Efforts to design a single litter stop which would fit all three types of coaming were unsuccessful. A revised litter stop was finally designed, however, which would fit both the Type II and Type III coaming. Inasmuch as a preponderant majority of the amphibian trucks then in use had coamings of these latter types, there was much to recommend this partial solution of the problem as a reasonably satisfactory expedient. Some thought was given to the possibility of providing a second litter stop, to be used exclusively on those vehicles equipped with Type I coaming, but this idea was subsequently discarded by the Laboratory as impracticable. Such a plan would have necessitated a separate stock of litter attachments, non-interchangeable with the standard type--a situation which, it was felt, would be likely to cause an unwarranted amount of difficulty for those charged with procurement of the item.⁵¹

The Laboratory decided, therefore, to abandon further experimental work on the project and to submit its revised litter stop design (adaptable to Types II and III coaming only) as the best practicable solution to the problem. Accordingly, on 14 October 1943, drawings, specifications, and a final written report on the new attachment were submitted to The Surgeon General's Office for its approval.⁵²

The Laboratory's report was an extremely informative one.⁵³ It began with a description of the preliminary examination and tests conducted at Carlisle Barracks to determine the general suitability of the amphibian truck as a litter bearing vehicle and to study various alternative methods of litter arrangement and loading sequence. After indicating the results of these tests, the report described the different litter securing devices which were investigated, the eventual selection of the manifold type of attachment as offering the greatest promise, the subsequent development of a specially designed four-section litter stop, and the service tests of the new device which were conducted shortly thereafter at Camp Edwards by the Engineer Amphibian Command. These test findings, it was pointed out, were favorable; but it was discovered that the original litter stop would not fit all amphibian DUKW's because of a variation in coaming construction of many of these vehicles. The problems encountered in the ensuing attempt to re-design litter stop so that this objection would be eliminated were discussed in some detail, and a careful explanation was given of the compromise

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solution finally decided upon.

Then followed a brief description of the item which was being presented for approval. The re-designed litter stop, it was explained, consisted of four identical sections, each measuring 74-3/8 inches in length and weighing 7.5 pounds. The device, which attached to the coaming of the DUKW and extended out from the sides to provide a stop for the litter handles, could be easily secured from either the outside or inside of the vehicle. When not in use, the four sections could be readily detached and stored under the cargo floor. Ropes, it was stated, would be needed only in movement over extremely rough water or terrain. As for protection against either rain or excessive surf spray, the middle bows on the amphibian truck (removed initially to provide head room in loading) could be left out of the vehicle and a canvas cover pulled forward on the longitudinal struts. The canvas, secured by the front ropes only, could quickly be thrown back to permit removal of litter patients in the event of emergency.

The loading plan recommended by the Laboratory for use with the above device bore a close resemblance to the plan proposed by Dennis Puleston at the outset of the project.⁵⁴ According to the new diagram, the first step was to attach two litter stop boards to the coaming on the opposite side of the vehicle from which the loading operation was to be performed. Litters 1 and 2 were then placed on the coamings, as far toward the front of the vehicle as possible, and pushed forward until their handles struck the litter stop. Next litters 3 and 4 were placed in an analogous position (at right angles to the sides of the vehicle and as far forward as possible) on the cargo floor. Litters 5, 6, and 7 were placed side by side on the cargo floor, parallel to the sides of the vehicle, and as far to the rear as possible. The lower tier litters were now all in position. If considered necessary they could be secured with rope. Litters 8, 9, 10, and 11 were then placed on the coaming behind litters 1 and 2, and the two litter stop boards on the loading side were pulled up and secured to the coaming. As an added precaution, litters 10 and 11 could be tied with a light rope to prevent sliding.

Essentially, the above plan differed from the Puleston plan in only two important respects. In the first place, under the new method the number of litters to be carried on the cargo floor had been reduced from six to five, thus affording needed additional clearance between the litters placed at the rear of this lower tier. In the second place, the loading sequence had been changed so that the two litters farthest forward on the coaming, or upper tier, were now moved into position first, instead of following

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the last of the lower tier litters as in the Puleston sequence. By this change the bearers, if forced to load the vehicle at a point some distance from the front of the coaming, could walk the necessary distance forward on the cargo floor without having to pick their way over and around casualties already moved into position.

In concluding its formal test report to The Surgeon General's Office, the Equipment Laboratory presented the following specific recommendations:

. . . It is recommended that the following be accepted for use by the Medical Department of the United States Army:

- a. Truck, $2\frac{1}{2}$ ton, 6x6 Amphibian for the Evacuation (Waterborne) of wounded.
- b. Litter loading arrangement as shown on Medical Department Equipment Laboratory Drawing No. C-436.
- c. Litter stop for Truck, $2\frac{1}{2}$ ton, 6x6, Amphibian (Medical Department Equipment Laboratory Drawing No. C-506).

Within a week the foregoing report and recommendations had received the approval of The Surgeon General's Office.⁵⁶ The new amphibian litter stop (see Fig. 20) was now ready for standardization.

III. Formulation of Military Characteristics.

Attention has been called earlier in this section to the somewhat informal procedures by which Development Project, F-30 was initiated.⁵⁷ One of the results of this initial failure to conform strictly to the provisions of AR 850-25 was a delay in formulating military characteristics beyond the date when such a formulation could have furnished any large measure of directional control over research and development personnel.

Equipment Laboratory officials were not requested to prepare a tentative draft of military characteristics until 2 August 1943,⁵⁸ and it was not until 18 September 1943 that the final statement had received the approval of Headquarters, Army Service Forces.⁵⁹ By this time, it will be recalled, design, construction, and service testing of the new litter stop had been virtually completed.

Whatever may be said of the Medical Department's tardiness in initiating this particular action, it was certainly true that, once processing action had begun, the pertinent provisions of AR 850-25 were carefully adhered to in all

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respects. On 2 August 1943, the Equipment Laboratory was directed by The Surgeon General's Office to prepare a brief statement of tentative military characteristics for the amphibian litter stop,⁶⁰ and on 7 August 1943, the data was forwarded for processing. Inasmuch as this initial draft of military characteristics was subsequently approved without change, the text will be quoted here in full.

The tentative military characteristics of this project are as follows:

a. To provide an attachment for the combing of the DUKW which will act as a litter stop thus affording for the proper carriage of litters.

b. The litter stop attachment shall be light in weight preferably not exceeding 20 pounds complete.

c. Provisions shall be made for the attachment to be placed on the combing of the DUKW quickly and with ease.

d. The attachment shall be carried with the DUKW at all times.

e. The attachment shall be simple in design and construction in order that it shall be inexpensive and easily procured.⁶¹

On 23 August 1943, the above statement of military characteristics was approved by the Medical Department Subcommittee,⁶² and on 6 September 1943 the Subcommittee report was in turn approved by the Medical Department Technical Committee.⁶³ A week later, the foregoing data was forwarded by The Surgeon General's Office to Headquarters, Army Service Forces,⁶⁴ and on 18 September 1943, final approval of military characteristics was granted by this authority.⁶⁵ As previously indicated, the Equipment Laboratory was notified of Army Service Forces' action on 21 September 1943.⁶⁶

IV. Standardization Phase I.

Upon receipt of the final test report from the Equipment Laboratory at Carlisle Barracks, recommending adoption of the new amphibian litter stop, action was promptly taken by The Surgeon General's Office to begin processing the item for standardization. As a first step, instead of sending a standardization request directly to the Medical Department Technical Subcommittee, the additional precaution was taken of clearing the recently received Carlisle test report with

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Headquarters, Army Service Forces.⁶⁷ Within a week, the following reply was received from the Requirements Division of that office:

1. The recommendations contained in the attached report of the Medical Department Equipment Laboratory on the Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded, are approved.

2. It is desired that appropriate action be taken through the Medical Corps Technical Committee towards standardization of the subject litter stop kit.⁶⁸

With the way ahead thus cleared, on 6 November 1943 the Medical Department Technical Subcommittee met and approved the following three recommendations: (1) that the new amphibian litter stop be adopted as a standard article; (2) that the item be made an integral part of all 2½-ton, 6x6, Amphibian Trucks now under procurement, and added to all such trucks currently in service; (3) that the litter stop be processed for standardization by the Ordnance Department Technical Committee.⁶⁹

In view of the fact that the Equipment Laboratory had already stated in its final test report that the new litter stop, while designed to fit all amphibian trucks with Types II and III coaming, would not be adaptable to the 281 vehicles equipped with Type I coaming, the Subcommittee's second recommendation--that the new attachment be added to "all subject trucks currently in service"--requires an explanation.

Since completing development work on the amphibian litter stop, the Equipment Laboratory had been making a closer study of the amphibian truck designs themselves in an effort to discover some practicable way of eliminating the existing variations in coaming. As it had not been possible to design a litter stop which would fit all DUKW types, perhaps the trucks themselves could be modified in certain minor respects.

This effort was successful. By November 1943, a modification of Type I coaming design had been worked out by Equipment Laboratory draftsmen which would, it was felt, adequately solve the problem. Direct action was thereupon taken to obtain official approval of these suggested changes in Ordnance specifications.

On 9 November 1943, the following memorandum was sent by The Surgeon General's Office to the Chairman of the Ordnance Technical Committee.

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1. Reference is made to the proposed action on Automotive Equipment, dated 1 October 1943, recommending approval of military characteristics for Truck, 2½-Ton, 6x6, Amphibian.

2. It is requested that a characteristic be added, to provide for uniform coaming on this vehicle, in order that its adaptation for the carrying of litters will not be jeopardized.⁷⁰

This communication was followed up, on 26 November 1943, when the Equipment Laboratory, at the request of The Surgeon General's Office, forwarded to the Technical Division, Office of the Chief of Ordnance, three sets of drawings, specifications, and phototraphs covering the proposed modifications of truck coamings.⁷¹

With this background in mind, the Subcommittee recommendation alluded to earlier--that the new litter stop attachment be added to all amphibian trucks currently in service--can be more readily understood. Moreover, in the light of the events just described, it was not surprising that the Medical Department Technical Committee, at a meeting held 22 November 1943, approved all Subcommittee recommendations without modification.

On 27 November 1943, all pertinent standardization data was forwarded by The Surgeon General's Office to Headquarters, Army Service Forces,⁷³ and two days later these papers were sent to the Technical Division, Office of The Chief of Ordnance, for appropriate action by the Ordnance Technical Committee.⁷⁴

V. Standardization Phase II.

A. First Modification of the Amphibian Litter Stop.

Thus far, Washington representatives of the Ordnance Department had been present at all Medical Department Technical Committee meetings held in connection with the amphibian litter stop. They had given their concurrence both to the statement of military characteristics formulated in September 1943⁷⁵ and to the recommendation for standardization of the item which was approved by the Committee in November 1943.⁷⁶ Apparently, however, liaison between the Washington office of the Chief of Ordnance and the Tank Automotive Center in Detroit, Michigan, had not been continuously and fully maintained during this period. The reaction of the latter agency to the standardization request it now received resembled, as will be seen below, the reaction of an agency considering the

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subject for the first time.

On 3 December 1943, Ordnance Department in Washington forwarded to the Chief of the Tank-Automotive Center, Detroit, all previous correspondence on the amphibian litter stop and requested a draft opinion as to the advisability of standardizing the item.⁷⁷ Upon receipt of this communication, the Tank-Automotive Center responded by first asking whether the Ordnance Department was to be responsible for procurement and distribution of the proposed litter stops, whether it was intended that such attachment be provided all amphibians, and, if so, what changes were contemplated in coaming construction to make this possible.⁷⁸ To these questions, Ordnance officials in Washington replied: (1) that the new litter stop assembly was to be purchased by Ordnance rather than by the Medical Department; (2) that all amphibians, including those in use and those to be manufactured, were to be equipped with the new attachment; and (3) that data covering proposed changes in Type I coaming (prepared by the Equipment Laboratory) had already been forwarded.⁷⁹

With these preliminary questions now settled, on 21 December 1943 the Tank-Automotive Center rendered its opinion regarding the new litter stops.⁸⁰ Its objections to the item developed by the Medical Department were several. First, it was stated that, while an alteration of Type I coaming had been prescribed by a Field Service Modification Work Order, the Center had been unable to determine the extent to which this order had been complied with by field units. It was believed that approximately 150 vehicles still included the original type coaming and, consequently, the Medical Department litter stop assemblies could not be used on any of these trucks.

Secondly, a number of technical objections were offered. It was stated that the litter stop adjusting rivet was too light for the purpose intended; that the provision of litter stop assemblies would add about 75 pounds to the weight of the amphibian, at a time when efforts were being made to lighten the vehicle; that addition of the litter stops to the height of the coaming added to the difficulty of lifting the litter in place; that, if bolted permanently to the coaming, the stops would interfere with cargo loading from ship-side and would undoubtedly be damaged during cargo loading operations in rough waters; finally, that the litter stops submitted would not necessarily prevent the end of a litter from bouncing and sliding rearward--perhaps to such an angle that the end of the litter might fall into the cargo compartment.

While many of the above criticisms were severe, and a few seemed even to question the need or desirability

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of litter stops in any form, the Tank-Automotive Center did, nevertheless, append certain constructive suggestions. It recommended, for example, that if such assemblies were to be provided they should be stowed in the bilge, between wheel housings, when the amphibian was being used as a cargo vehicle. This method, as contrasted with permanent installation, would reduce the danger of damage to personnel and to the stops themselves during loading operations.

As for the type of litter stop suitable for adoption, however, the Tank-Automotive Center proposed that the answer to that question be left open for further investigation.

3. As this office will be required to furnish litter stops for the amphibians, it is investigating promptly optional designs which it is intended will obviate the deficiencies outlined in paragraph 2, preceding. From a cursory study of the problem, one method has been suggested in the form of litter caps shown on GMC layout MD-12658 inclosed. These caps could be stowed readily in new amphibians and furnished for all amphibians in the field. They would fit on all amphibians, except those early vehicles that have not yet had coamings altered, and a modified type could be produced to fit those amphibians. The weight of a set of 24 caps would not be over 10 pounds; a weight low enough to permit several spares being provided

4. To assist this office in this study, it is requested that the Medical Department furnish promptly detailed data covering the size and shape of the handles on every type of litter it is expected will be carried on the amphibians. Further, the Medical Department might comment on the possibility that some form of handle caps might be adopted as a substitute for litter stops C-506.⁸¹

Wherever the responsibility lay for this anomalous situation, in which research proposals of a type normally presented at the beginning of a development project were instead being offered at a point near its termination, it was clear to the Medical Department, as soon as it had learned of the reaction of the Ordnance office at Detroit, that action must be taken quickly and that a solution would be hastened by a face-to-face meeting between all interested parties. Accordingly, on 21 January 1944 a teletype message was dispatched from The Surgeon General's Office to The Deputy Chief of Ordnance in Detroit, announcing that a

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representative of the Medical Department Equipment Laboratory would arrive in Detroit the first of the following week to attend a conference with Ordnance officials on the subject of the amphibian litter stops.⁸²

The above-mentioned meeting at Detroit took place on 24 January 1944 and was attended by representatives of the Medical Department, Ordnance Department, and officials of the General Motors Corporation, manufacturers of the amphibian truck. At this conference three types of litter stops were discussed: (1) a new type, permanently welded to the coaming; (2) the litter-cap type of device as developed by General Motors Corporation; and (3) the litter stop developed by the Equipment Laboratory.⁸³

The permanently welded type was secured to the outer surface of the coaming and, when not in use, the fastener swung down from the top of the coaming and was secured by a pin. The fastener extended out from the side of the coaming approximately $1\frac{1}{2}$ inches in both the vertical and horizontal position. Inasmuch as the side deck of the amphibian was only 5 inches wide, with the $1\frac{1}{2}$ -inch projection of the litter fastener this space was reduced to $3\frac{1}{2}$ inches at the fastener. Moreover, not only was the walking space thus reduced, but the projections along the side of the vehicle offered a constant source of injury to the men walking the side deck. Finally, it was observed that while this type of fastener could be readily secured to the amphibian at the factory, special equipment would be required to install the attachment in the field.

The litter-cap type of assembly, designed by General Motors, has already been briefly described.⁸⁴ Suffice it to say here that the item was now definitely rejected. As the Equipment Laboratory had discovered for itself some months before, the representatives present at length agreed that this type of litter stop would have the serious dual disadvantages of having to be removed by the litter bearers each time a litter was placed, and of being quite easily lost when the litter was removed from the coaming.

By process of elimination, then, the Equipment Laboratory design was the only remaining alternative. It was pointed out by the Laboratory that this litter stop could be easily and securely attached to the coaming of the amphibian by three clamps per board, or six clamps per side of the vehicle. Moreover, the boards would give full protection along the whole side of the amphibian regardless of the position of the litter. Short enough to be easily handled, each section or board could, if desired, be stored when not in use under the cargo deck of the amphibian.

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As a result of the above comparison, it was stated to be the opinion of the group that the Equipment Laboratory model was the most practicable litter stop of the three types studied. However, several changes in the drawings were suggested by General Motors officials, and these were accepted and approved by the Medical Department representative. It was agreed, as suggested in the above paragraph, that the assembly would not be permanently attached to the coaming of the amphibian, but would be removable so that it could be stored below deck during cargo transport and during cargo loading and unloading. Another valuable suggestion was a recommended alteration in bracket spacing to conform to a recent change in the position of the vehicle's tarpaulin bows. The new amphibian trucks were being built with five cross bows instead of four, as was the case with certain of the older models. Finally, several changes in construction materials were suggested, such as the substitution of brass for steel in certain parts of the litter stop.

All in all, the conference had been a most fruitful one. Not only had the main outstanding differences been resolved, but the Medical Department litter stop itself had been improved in the process. Accordingly, on 19 February 1944 a report of the conference was forwarded by The Surgeon General's Office to the Requirements Division, Army Service Forces, with the recommendation that the litter stop developed by the Equipment Laboratory, as modified by the suggestion of General Motors Corporation, be accepted for standardization.⁸⁵ This recommendation was approved and was promptly forwarded to the Office of The Chief of Ordnance in Washington.⁸⁶ Meanwhile, on 17 February 1944, the Ordnance office in Detroit, in a letter to Ordnance headquarters, confirmed the conference decisions as outlined above and inclosed advance copies of the revised litter stop drawings.⁸⁷

All that now remained to be accomplished was the settlement of a few remaining procurement details. The Surgeon General's Office had originally proposed that litter stops be purchased for all amphibians in use, in process of manufacture, and to be manufactured.⁸⁸ This request was now modified. All new vehicles were to be provided with the litter stops, but only fifty percent of those which had already left the factory were to be so equipped. No attempt was to be made to equip the estimated 150 vehicles still retaining the old Type I coaming.⁸⁹

Only a slight revision of this plan was suggested by the Ordnance Department. By the time the new litter stops could become a production item, it was estimated that over 6,000 amphibians would have been delivered. It was now proposed that an initial order of only 2,500 kits, instead of 3,000, be placed to cover field requirements. Operating

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personnel would meanwhile be informed of the availability of the new attachments; and, if more than 2,500 kits were requested, requisitions could then be filled promptly. At the earliest possible moment the litter stop would be included as an "on-vehicle-material" item, in order to keep to a minimum the quantity of separate kits issued.⁹⁰

This counter-proposal was approved by The Surgeon General's Office on 11 March 1944,⁹¹ and it now appeared that at last all development and standardization problems had been solved.

B. Second Modification of the Amphibian Litter Stop.

One final interchange of ideas between the General Motors Corporation and the Medical Department, however, was to take place before production of the new litter stops was initiated. Once again collaboration between these two agencies resulted in a further improvement of the item in question, although a delay of several months was occasioned by the action.

On 2 March 1944, a representative of The Surgeon General's Office visited the Office of the Chief of Ordnance in Detroit and inspected the final drawings of the amphibian litter stop which had been prepared by General Motors Corporation.⁹² It was discovered that the new drawings not only incorporated the various changes previously agreed to, but that certain other structural modifications had been made which, although of a minor nature, represented a further improvement over the original Carlisle model and would definitely increase the ease of manufacture.

The General Motors drawings were duly forwarded to the Medical Department Equipment Laboratory for study and, on 16 March 1944, that office expressed its approval of the amended design.⁹³ Careful examination of the drawings, it was stated, showed the proposed attachment to be simpler in construction than the Laboratory model, and it was also felt that the item as now modified would be as durable as its predecessor. It was agreed that the simplicity of the new model from a manufacturing standpoint was an advantage of sufficient importance to justify its adoption.

Aside from a few minor suggestions of a technical nature, no objection to the General Motors revisions was made by the Laboratory. On 22 April 1944 these suggested changes were forwarded by The Surgeon General's Office to the Office of The Chief of Ordnance in Detroit,⁹⁴ and on 17 May 1944 a final revision of drawings on the basis of Equipment Laboratory recommendations was agreed to by General Motors Corporation and the Ordnance Department.⁹⁵

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VI. Evaluation.⁹⁶

Compared with the two projects previously discussed in this chapter,⁹⁷ Development Project, F-30 was in a number of respects a much more satisfactory research performance. Except for the standardization phase, it had been more effectively administered; had been completed in a much shorter time; and, in addition, had yielded at least as satisfactory an end-product as either of the aforementioned undertakings.

It is true, of course, that in the development of the amphibian litter stop certain serious lapses had occurred, both in the carrying out of substantive research and in the handling of formal procedural matters. The initial project proposal, for example, had not been processed through the Medical Department Technical Committee, with the result that the project had been established before official concurrence of the other Technical Services had been obtained and before a definite statement of military characteristics had been formulated and approved. Project completion had been delayed several months by the failure to establish at an earlier date direct liaison relationships with the Ordnance Department (especially the Tank-Automotive Center in Detroit) and with General Motors Corporation. The responsibility for these particular omissions, however, was divided. It rested partly with the Medical Department which had neglected to include the above agencies in its original request to Headquarters, Army Service Forces, for direct liaison privileges, and partly with the Office of The Chief of Ordnance in Washington which had evidently failed to keep its Detroit offices fully informed regarding the progress of the experimentation. Finally, a delay had been caused by the failure on the part of Equipment Laboratory officials to familiarize themselves with the construction details of all amphibian trucks then in use by the Army, before beginning actual development work.

Despite the above shortcomings, there was much to be added on the credit side of the ledger. While the initiation of Development Project, F-30 had not been carried out in complete conformance with the provisions of AR 850-25, considerable coordination had nevertheless been accomplished outside the Medical Department Technical Committee. In the first place, the original initiation request had come to the Medical Department directly from the Requirements Division, Headquarters, Army Service Forces, which, in turn, had already cleared the proposal with the Assistant Chief of Staff, G-4. Furthermore, this last-named office had been in previous contact with the Transportation Division of the Office of Scientific Research and Development, which had been (along with the Engineer Amphibian Command) largely instrumental in the development of the DUKW and was even then conducting preliminary experimental

work aimed at adapting the amphibian truck to ambulance use. Finally, the initial project proposal had been carefully cleared through all interested agencies within The Surgeon General's Office before formal establishment of the project was requested.

As for other processing actions, all were carried out in strict accordance with Army Regulations. Both the formulation of military characteristics and the final processing of the item for standardization were cleared through the Medical Department Technical Committee and through all prescribed higher echelons of command. Moreover, at the specific request of the Medical Department and at the very outset of the project, a close working liaison was established with the Engineer Amphibian Command of Fort Edwards, Massachusetts. Through this joint arrangement, not only were testing activities completed in an unusually short period of time, but on-the-spot observation of these trials by an Equipment Laboratory representative led to an early discovery of the unsuspected variation in truck coamings, and this, in turn, led to an earlier modification of the only major structural defect in the new litter stop.

Finally, something should be said of the positive action taken by The Surgeon General's Office as soon as it learned that standardization of the Carlisle model litter stop had been disapproved by the Tank-Automotive Center. Arrangements were immediately made for a conference to be held at Detroit between representatives of the Medical Department, Ordnance Department, and General Motors Corporation. By this action, agreement on a highly controversial issue was reached in a matter of days. In previous projects, months had often been required. Again, at the time of the suggested second modification of the amphibian litter stop, the presence of a Medical Department representative at the Office of the Chief of Ordnance, Detroit, was a decided advantage. As a result of this advance coordination, the proposed change in drawings was subsequently cleared through all necessary channels with a minimum of difficulty.

As for the end-item itself, the amphibian litter stop appears to have satisfied the expectations of all concerned. The attachment has been listed by the Director of the Medical Department Equipment Laboratory and by the Director of the Technical Division of The Surgeon General's Office as one of the most successful litter adapters developed by the Medical Department during the World War II period;⁹⁸ and it would appear, judging from the preceding account, that the new litter stop received the full approval of the Engineer Amphibian Command, Ordnance Department, and the prospective manufacturer, General Motors Corporation.

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FOOTNOTES TO CHAPTER IV, SECTION 3

- ¹ FM-8-25, Medical Service in Joint Oversea Operations, 28 Mar. 1940, RESTRICTED. Extracted in clear.
- ² Ibid., pp. 19-20.
- ³ Interview with Buell B. Whitehill, Jr., 1st Lt., M.A.C., Medical Historian, Central Pacific Area, 8 Apr. 1946.
- ⁴ Memo. to CG, A.S.F. (Attention: Requirements Div.), fr. W.D.G.S., G-4, 31 Mar. 1943; subject: "Use of 2½-ton Amphibian as an Ambulance," RESTRICTED (W.D.G.S. 3183, Office of G-4). Extracted in clear.
- ⁵ Memo. to T.S.G., fr. Dir., Requirements Div., A.S.F., 1 Apr. 1943; subject: "Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded" (Rec. Rm., S.G.O. 451.2-1 Carlisle Bks.-N).
- ⁶ Draft copy of 1st Ind. to CG, Hq., A.S.F., fr. S.G.O., 8 Apr. 1943; basic: see n. 5 (A.M.R. & D. Bd.).
- ⁷ Memo. to Gen. McAfee, Asst. Surg. Gen., fr. Hosp. & Evac. Div., S.G.O., 9 Apr. 1943 (A.M.R. & D. Bd.).
- ⁸ 1st Ind. to CG, A.S.F., fr. S.G.O., 10 Apr. 1943; basic: see n. 5 (Rec. Rm., S.G.O. 451.2-1 Carlisle Bks.-N).
- ⁹ 2d Ind. to T.S.G., fr. Dir., Requirements Div., A.S.F., 15 Apr. 1943; basic: see n. 5 (Rec. Rm., S.G.O. 451.2-1 Carlisle Bks.-N).
- ¹⁰ 3d Ind. to M.D.E.L., fr. S.G.O., 22 Apr. 1943; basic: see n. 5 (Rec. Rm., S.G.O. 451.2-1 Carlisle Bks.-N).
- ¹¹ Min. of M.D.T.C., Meeting No. 7, 28 Jun. 1943, RESTRICTED. Extracted in clear.
- ¹² Ibid..

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- 13 1st Ind. to T.S.G., fr. Chf., Development Br., Requirements Div., Hq., A.S.F., 17 Apr. 1943 (A.P.R.M.D. 334.8 Office of Research & Development Div., A.S.F.); basic: ltr. to CG, A.S.F. (Attention: Requirements Div.), fr. W.D.G.S., G-4, 14 Apr. 1943; subject: "Use of the DUKW as an Ambulance," RESTRICTED (W.D.G.S. 3361, Office of G-4). Extracted in clear.
- 14 AR 850-25, 23 Jul. 1936. This regulation was completely revised on 30 June 1943, but the role of the Technical Committees remained essentially unchanged.
- 15 Military characteristics were not officially approved until 18 Sep. 1943. See 1st Ind. to T.S.G. (Attention: Research Coordination Br.), fr. Acting Dir., Requirements Div., Hq., A.S.F., 18 Sep. 1943; basic: ltr. to CG, A.S.F. (Attention: Chf., Development Br., Requirements Div.), fr. Chf., Operations Service, S.G.C., 13 Sep. 1943; subject: "Truck, 2½-ton, 6x6, Amphibian, for Waterborne Evacuation of Wounded" (Rec. Rm., S.G.C., 451.2).
- 16 See n. 14.
- 17 Ltr. to W.D.G.S., fr. Office of Research & Development, Washington, D.C., 12 Apr. 1943 (M.D.E.L.). Note particularly the first paragraph which refers to previous conversations on the subject of converting the DUKW to an amphibian ambulance.
- 18 Transmittal Sheet to Clin J. Stephens III (Sparkman & Stephens, Boston, Mass.), fr. Dennis Fuleston, Amphibious Vehicle Training School, Charleston, S.C., 5 Apr. 1943 (Nat'l. Defense Research Comm., Office of Scientific Research & Development). Incl. 1 to above communication, "Proposed Use of DUKWs in Evacuation of Casualties from Bridgehead to Ship's Deck," 4 Apr. 1943, RESTRICTED (M.D.E.L.). Extracted in clear.
- 19 See n. 17.
- 20 Ltr. with Incls. to CG, A.S.F. (Attention: Requirements Div.), fr. W.D.G.S., G-4, 14 Apr. 1943; subject: "Use of the DUKW as an Ambulance," RESTRICTED (W.D.G.S. 3361, Office of G-4). Extracted in clear.
- 21 1st Ind. to T.S.G., fr. Chf., Development Br., Requirements Div., Hq., A.S.F., 17 Apr. 1943, RESTRICTED; basic: see n. 20 (A.P.R.M.D. 334.8 Hq., A.S.F.). Extracted in clear.

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- 22 3rd Ind. with Incls. to M.D.E.L., fr. S.G.O., 22 Apr. 1943;
basic: see n. 5 (M.D.E.L.).
- 23 Ltr. to Hist. Div., S.G.O., fr. M.D.E.L., 13 Dec. 1945;
subject: "Truck, 2½ Ton, 6x6, Amphibian for Water Borne
Evacuation of Wounded, Medical Department Equipment Labo-
ratory Project F 30," Incl. 1 (Hist. Div., S.G.O.).
- 24 Monthly Narrative Report, M.D.E.L., 1 - 31 May 1943 (A.M.R.
& D. Bd.). See, also, ltr. to S.G.O., fr. M.D.E.L., 14 Oct.
1943; subject: "Truck 2½ ton, 6x6, Amphibian for Waterborne
Evacuation of Wounded" (M.D.E.L.).
- 25 Ibid.
- 26 Ibid.
- 27 For a brief discussion of the disadvantages of the clip or
cap type of fastener, see 6th Ind. to CG, A.S.F. (Attention:
Requirements Div.), fr. Operations Service, S.G.O., 19 Feb.
1944; basic: ltr. to CG, A.S.F. (Attention: Chf., Develop-
ment Br., Requirements Div.), fr. Operations Service, S.G.O.,
27 Nov. 1943; subject: "Litter Stop Attachment for Truck,
2½-ton, 6x6, Amphibian (DUKW)" (Rec. Rm., S.G.O. 451.2-1).
- 28 See n. 24.
- 29 Monthly Narrative Report, M.D.E.L., 1 - 31 May 1943 (A.M.R.
& D. Bd.).
- 30 Ltr. to Engineering Amphibian Command, fr. M.D.E.L., 9 Jun.
1943 (M.D.E.L.).
- 31 See n. 29.
- 32 Monthly Narrative Report, M.D.E.L., 1 - 30 Jun. 1943 (M.D.E.L.).
- 33 Ibid.
- 34 See Chapter IV, Sec. 1, this study.
- 35 Ltr. to Tank-Automotive Center, Detroit, Mich., fr. M.D.E.L.,
17 Jun. 1943 (M.D.E.L.).

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- 36 Ltr. to M.D.E.L., fr. British Joint Staff Mission, Offices of the Combined Chiefs of Staff, 4 Jun. 1943, CONFIDENTIAL (A.M.R. & D. Bd.). Extracted in clear.
- 37 Ltr. to Engineering Amphibian Command, Cp. Edwards, Mass., fr. M.D.E.L., 9 Jun. 1943 (M.D.E.L.).
- 38 Ltr. to M.D.E.L., fr. Engineering Amphibian Command, Cp. Edwards, Mass., 5 Jul. 1943; subject: "Use of Amphibian, 2½ ton, 6x6, Trucks as Ambulances" (M.D.E.L.).
- 39 Ibid.
- 40 See n. 37.
- 41 See n. 38.
- 42 Ibid.
- 43 See n. 35.
- 44 1st Ind. to Hq., Engineering Amphibian Command, Camp Edwards, Mass., fr. M.D.E.L., 7 Jul. 1943; basic: see n. 38 (M.D.E.L.).
- 45 2d Ind. to M.D.E.L., fr. Hq., Engineering Amphibian Command, Camp Edwards, Mass., undated; basic: see n. 38 (M.D.E.L.).
- 46 1st Ind. to M.D.E.L., fr. Tank Automotive Center, Detroit, Mich., 21 Jul. 1943; basic: see n. 35 (M.D.E.L.).
- 47 Ltr. to Tank Automotive Center, Detroit, Mich., fr. M.D.E.L., 5 Aug. 1943; subject: "Amphibian Truck, 6x6, DUKW, 2½ ton, GMC" (M.D.E.L.).
- 48 1st Ind. to M.D.E.L., fr. Tank Automotive Center, Detroit, Mich., 26 Aug. 1943; basic: see n. 47 (M.D.E.L.).
- 49 Ltr. to Dir., M.D.E.L., fr. S.G.C., 21 Sep. 1943; subject, "Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded" (Rec. Rm., S.G.C. 451.2-1 Carlisle Barracks-N). See incls.

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- 50 Ltr. to S.G.O., fr. M.D.E.L., 14 Oct. 1943; subject: "Truck, 2½ Ton, 6x6, Amphibian for Waterbourne Evacuation of Wounded" (A.M.R. & D. Bd.).
- 51 Ibid.
- 52 Ibid.
- 53 Ibid. The remarks which follow are drawn from this test report.
- 54 Supra., pp. 265-267.
- 55 See n. 50.
- 56 Ltr. to CG, A.S.F. (Att: Requirements Div.), fr. S.G.O., 23 Oct. 1943; subject: "Truck, 2½-ton, 6x6, Amphibian, for Waterborne Evacuation of Wounded" (A.M.R. & D. Bd.).
- 57 Supra., pp. 262-264.
- 58 Ltr. to M.D.E.L., fr. S.G.O., 2 Aug. 1943; subject: "Request for Military Characteristics" (A.M.R. & D. Bd.).
- 59 1st Ind. to T.S.G., fr. Reqts. Div., Hq., A.S.F., 18 Sep. 1943; basic: ltr. to CG, A.S.F. (Att: Chf., Develop. Br., Reqts. Div.), fr. S.G.O., 13 Sep. 1943; subject: "Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded" (A.M.R. & D. Bd.).
- 60 See n. 58.
- 61 1st Ind. to T.S.G., fr. M.D.E.L., 7 Aug. 1943; basic: see n. 58 (A.M.R. & D. Bd.).
- 62 Ltr. to M.D.T.C., fr. Med. Dept. Tech. Subcomm., 23 Aug. 1943; subject: "Truck, 2½-Ton, 6x6, Amphibian for Waterborne of Wounded" (A.M.R. & D. Bd.).
- 63 Min. of M.D.T.C., 6 Sep. 1943, RESTRICTED, pp. 7-8 (Hist. Div., S.G.O.). Extracted in clear.

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64 Ltr. to CG, A.S.F. (Att: Chf., Develop. Br., Repts. Div.), fr. S.G.O., 13 Sep. 1943; subject: "Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded" (A.M.R. & D. Bd.).

65 See n. 59.

66 Memo. to Chf., Field Equip. Develop. Br., S.G.O., fr. Research Coord. Br., Plans Div., S.G.O., 30 Sep. 1943; subject: "Truck, 2½-Ton, 6x6, Amphibian for Waterborne Evacuation of Wounded" (A.M.R. & D. Bd.).

67 Memo. to CG, A.S.F. (Att: Repts. Div.), fr. S.G.O., 23 Oct. 1943; subject: "Truck, 2½-ton, 6x6, Amphibian, for Waterborne Evacuation of Wounded" (A.M.R. & D. Bd.).

68 1st Ind. to T.S.G. (Att: Research Coord. Br.), fr. Actg. Dir. Materiel, Hq., A.S.F., 28 Oct. 1943; basic: see n. 67 (A.M.R. & D. Bd.).

69 Ltr. to M.D.T.C., fr. Med. Dept. Tech. Subcomm., 6 Nov. 1943; subject: "Litter Stop Attachment for Truck, 2½-Ton, 6x6, Amphibian (DUKW)" (A.M.R. & D. Bd.).

70 Memo. to Chairman, Ordnance Tech. Comm., fr. S.G.O., 9 Nov. 1943; RESTRICTED, subject: "Military Characteristics for Truck, 2½-Ton, 6x6, Amphibian" (A.M.R. & D. Bd.). Extracted in clear.

71 1st Ind. to S.G.O., fr. M.D.E.L., 26 Nov. 1943; basic: memo. to Dir., M.D.E.L., fr. S.G.O., 23 Nov. 1943; subject: "Request for Specifications, Drawings and Photographs, Truck, 2½-ton, 6x6, Amphibian (DUKW)" (A.M.R. & D. Bd.).

72 Min. of M.D.T.C., 22 Nov. 1943, RESTRICTED (Hist. Div., S.G.O.). Extracted in clear.

73 Ltr. to CG, A.S.F. (Att: Chf., Develop. Br., Repts. Div.), fr. S.G.O., 27 Nov. 1943; subject: "Litter Stop Attachment for Truck, 2½-ton, 6x6, Amphibian (DUKW)" (Rec. Rm., S.G.O. 451.2-1).

74 1st Ind. to Chf. Ordnance Dept. (Att: Tech. Div.), 29 Nov. 1943; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1).

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75 See n. 63.

76 See n. 72.

77 2nd Ind. to Chf., Tank-Automotive Center, Detroit, Mich., fr. Transport Develop. Liaison Br., Ordnance Dept., 3 Dec. 1943; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1).

78 1st Ind. to Chf., Ordnance Dept., Wash. D.C., fr. Tank-Automotive Center, Detroit, Mich., 6 Dec. 1943; basic: ltr. to Tank-Automotive Center, Detroit, Mich., fr. Off. Chf. of Ordnance, Wash., D.C., 27 Nov. 1943 (M.D.E.L.).

79 2nd Ind. to Tank-Automotive Center, Detroit, Mich., fr. Chf., Ordnance Dept., Wash., D.C., undated; basic: ltr. to Tank-Automotive Center, Detroit, Mich., fr. Off. Chf. of Ordnance, Wash., D.C., 27 Nov. 1943 (M.D.E.L.).

80 3rd Ind. to Office, Chf. of Ordnance, Wash., D.C., fr. Tank-Automotive Center, Detroit, Mich., 21 Dec. 1943; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1). The discussion which follows is taken from this document.

81 Ibid.

82 TWX to Off. of Dep. Chf. of Ordnance, Detroit, Mich., fr. Plans Div., S.G.O., 21 Jan. 1944 (A.M.R. & D. Bd.).

83 6th Ind. to CG, A.S.F. (Att: Repts. Div.), fr. Operations Serv., S.G.O., 19 Feb. 1944; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1).
Monthly Narrative Report, M.D.E.L., 1 Jan. 1944 - 31 Jan. 1944 (M.D.E.L.). The discussion which follows is drawn largely from these two documents.

84 Supra., p. 281.

85 6th Ind. to CG, A.S.F. (Att: Repts. Div.), fr. Operations Serv., S.G.O., 19 Feb. 1944; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1).

86 7th Ind. to Ordnance Dept., Wash., D.C., fr. CG, A.S.G., 23 Feb. 1944; basic: see n. 73 (Rec. Rm., S.G.O. 451.2-1).

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- 87 Memo. to Off., Chf. of Ordnance, Wash., D.C., fr. Off., Chf. of Ordnance, Detroit, Mich., 17 Feb. 1944; subject: "Litter Stop Assembly on 2½ Ton, 6x6 Amphibian" (Rec. Rm., S.G.O. 451.2-1).
- 88 See n. 73.
- 89 See n. 85.
- 90 See n. 87.
- 91 3d Ind. to CG, A.S.F. (Att: Repts Div.), fr. Chf., Operations Serv., S.G.O., 11 March 1944; basic: see n. 87 (Rec. Rm., S.G.O. 451.2-1).
- 92 Ltr. to T.S.G., fr. M.D.E.L., 16 Mar. 1944 (Rec. Rm., S.G.O. 451.2-1 Carlisle Barracks-N).
- 93 Ibid.
- 94 Memo. to Off., Chf. of Ordnance, Detroit, Mich., fr. Operations Serv., S.G.O., 22 Apr. 1944; subject: "Litter Stop, Amphibian, Truck, 2½-ton, DUKW" (Rec. Rm., S.G.O. 451.2-1).
- 95 1st Ind. (Memo) to S.G.O., fr. Off., Chf. of Ordnance, Detroit, Mich., 17 May 1944; basic: see n. 94 (A.M.R. & D. Bd.).
- 96 The subjects of procurement and distribution are not discussed in this study, as these phases were handled by Ordnance Department as part of its Amphibian Truck program.
- 97 Development Project, F-28, "Litter, Ski," and Development Project, F-29, "Ambulance, Snow and Ice."
- 98 See consolidated list of selected projects, prepared after individual interview with Colonel E.D. Quinnell, Dir., M.D.E.L. and Lt. Col. John B. Klepp, Dir., Tech. Div., S.G.O. (Hist. Div., S.G.O.).

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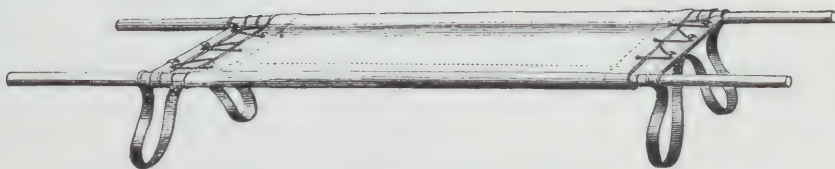
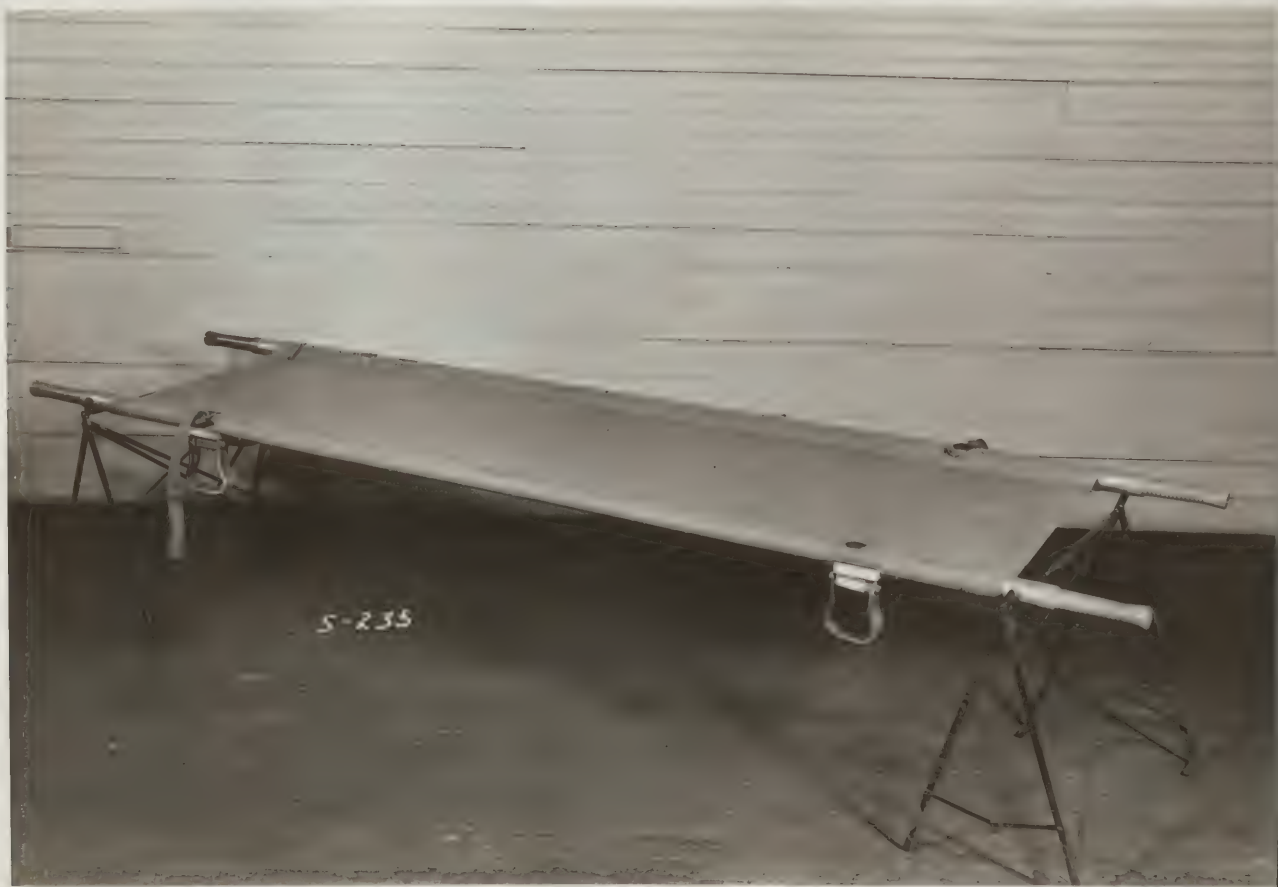


FIG. 2 —SATTERLEE or Regulation hand litter.

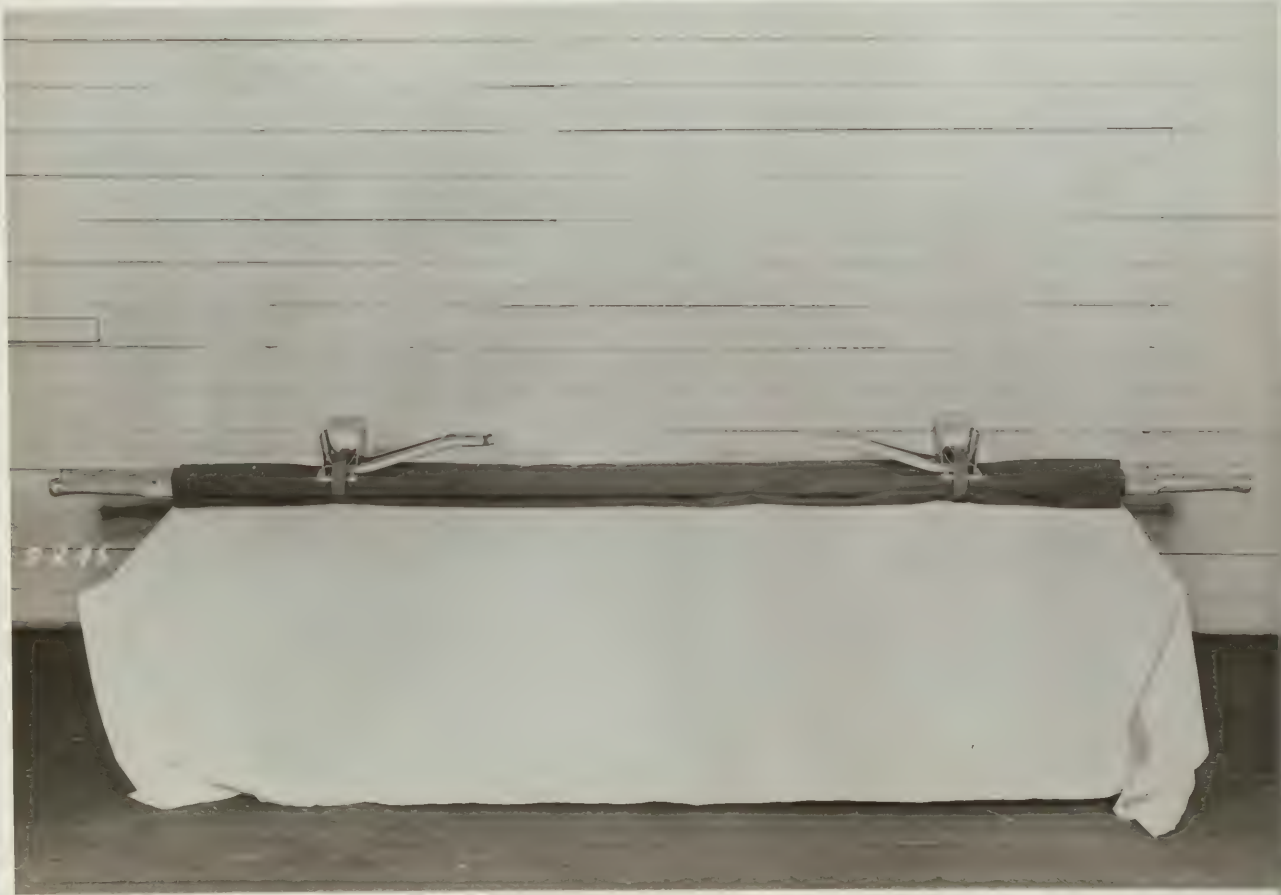


FIG. 3 —HALSTEAD's litter.







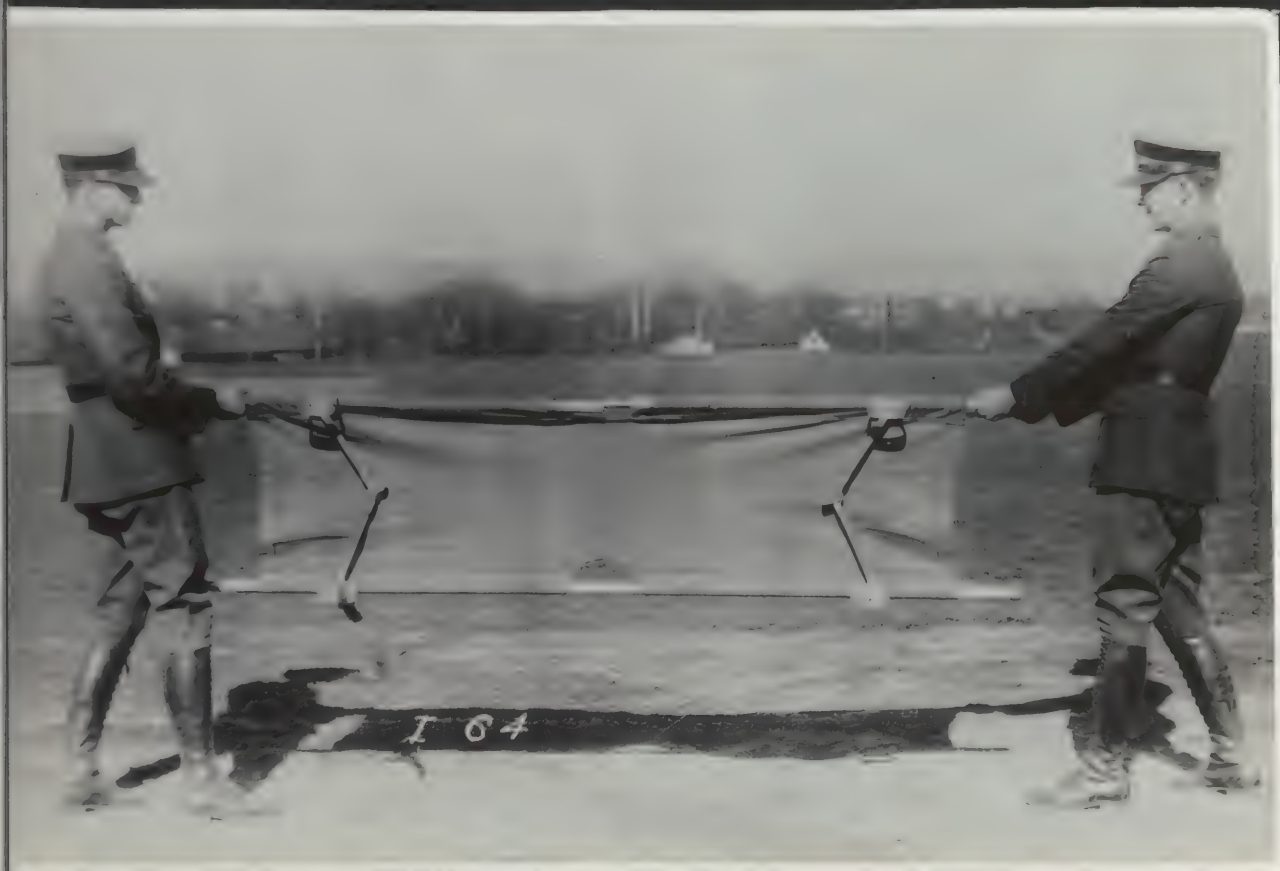


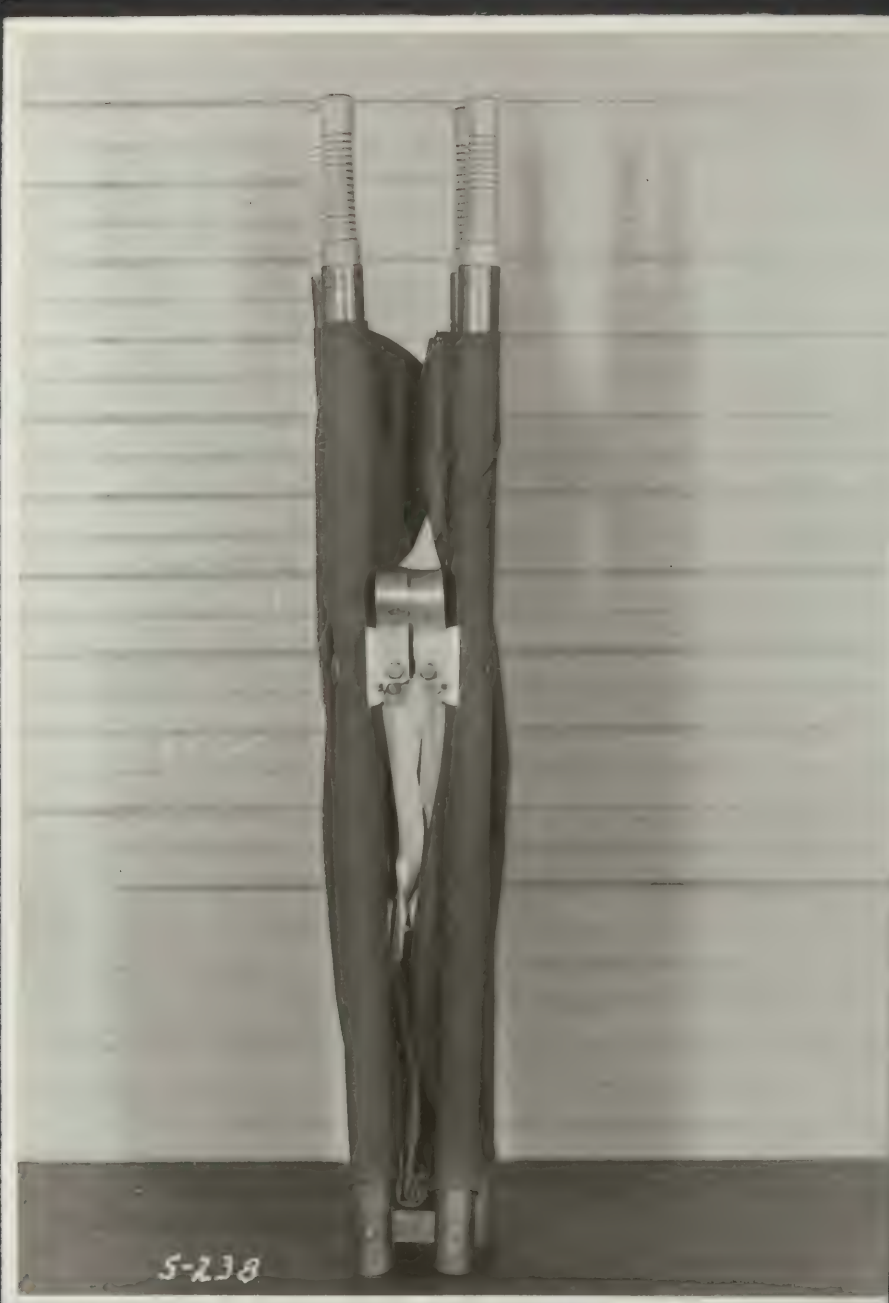




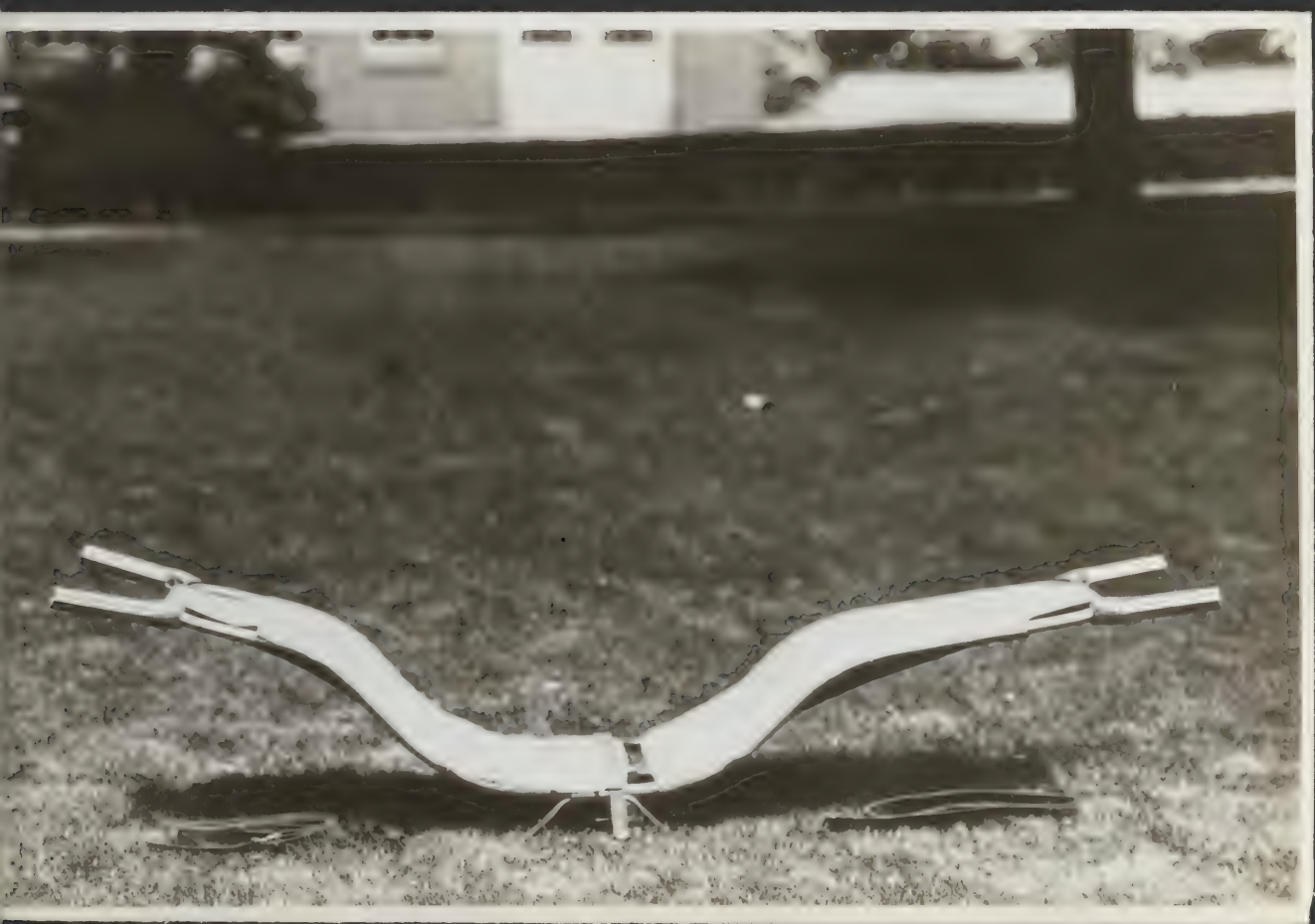
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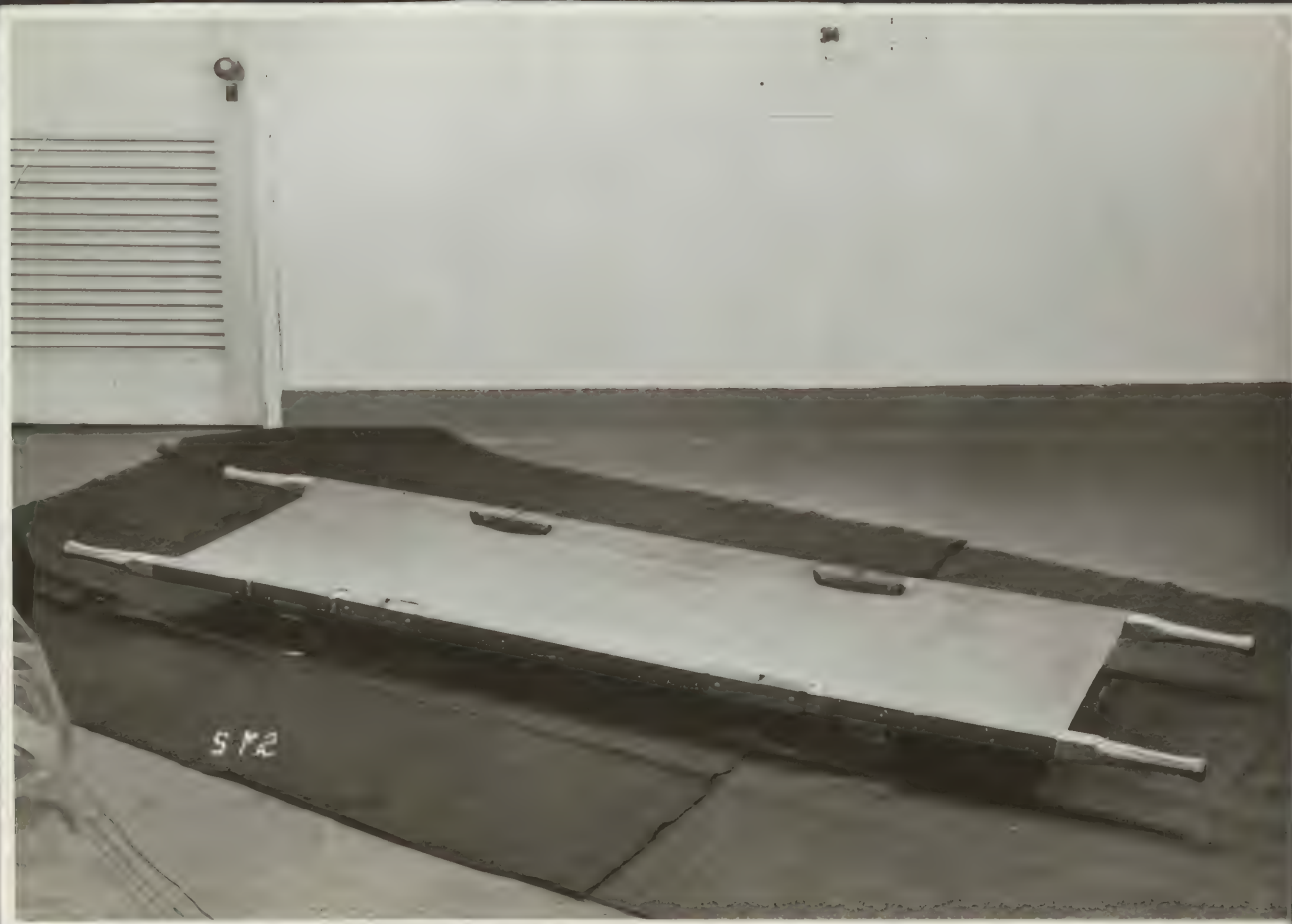
RESEARCH AND ANALYSIS
UNITED STATES DEPARTMENT OF AGRICULTURE
WASHINGTON, D. C.

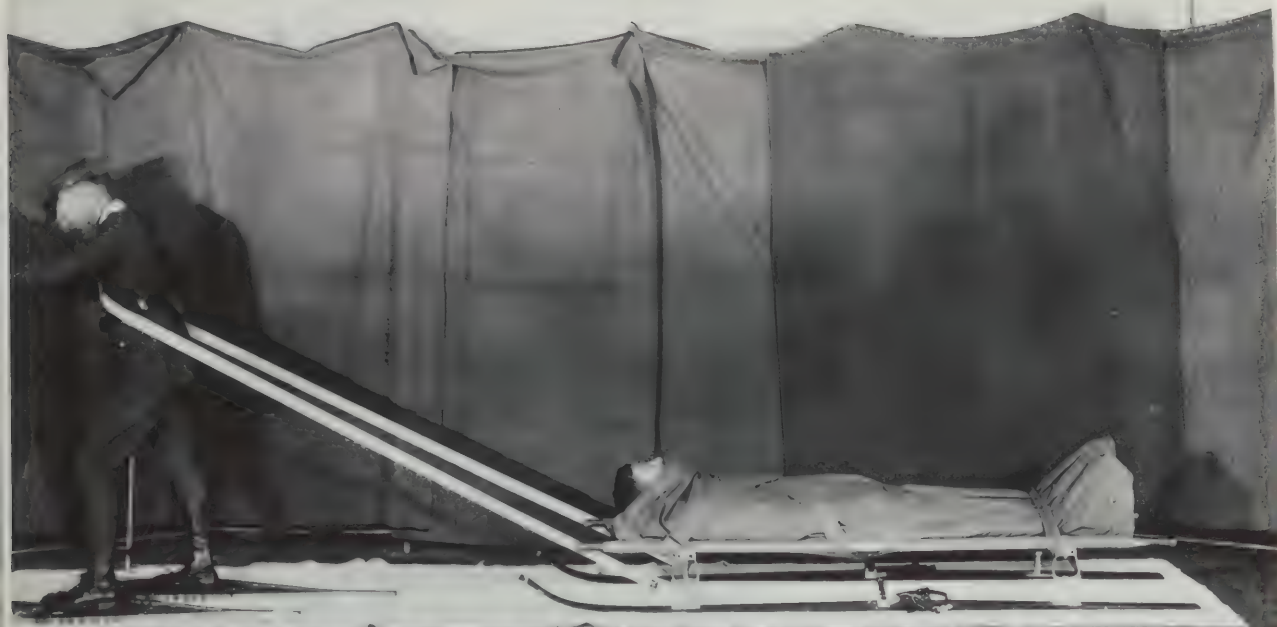




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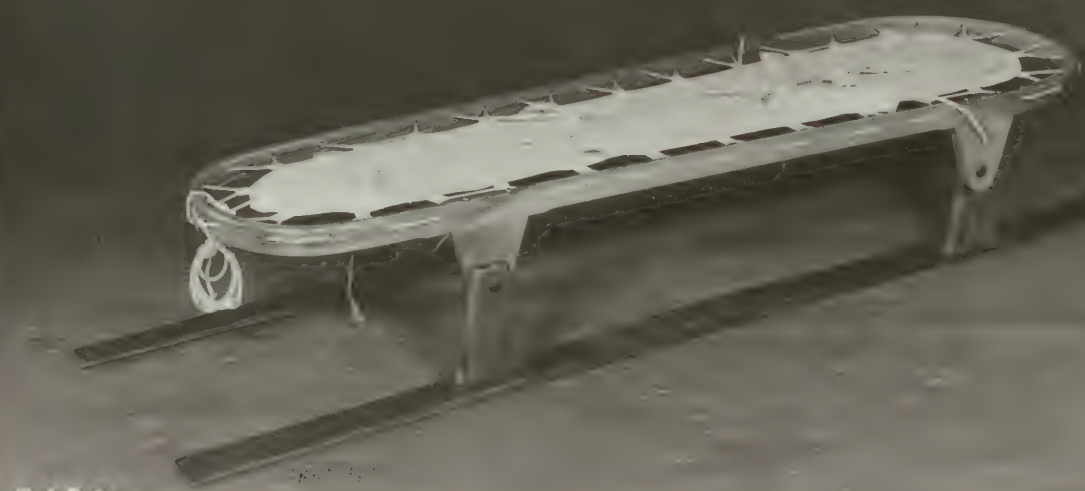






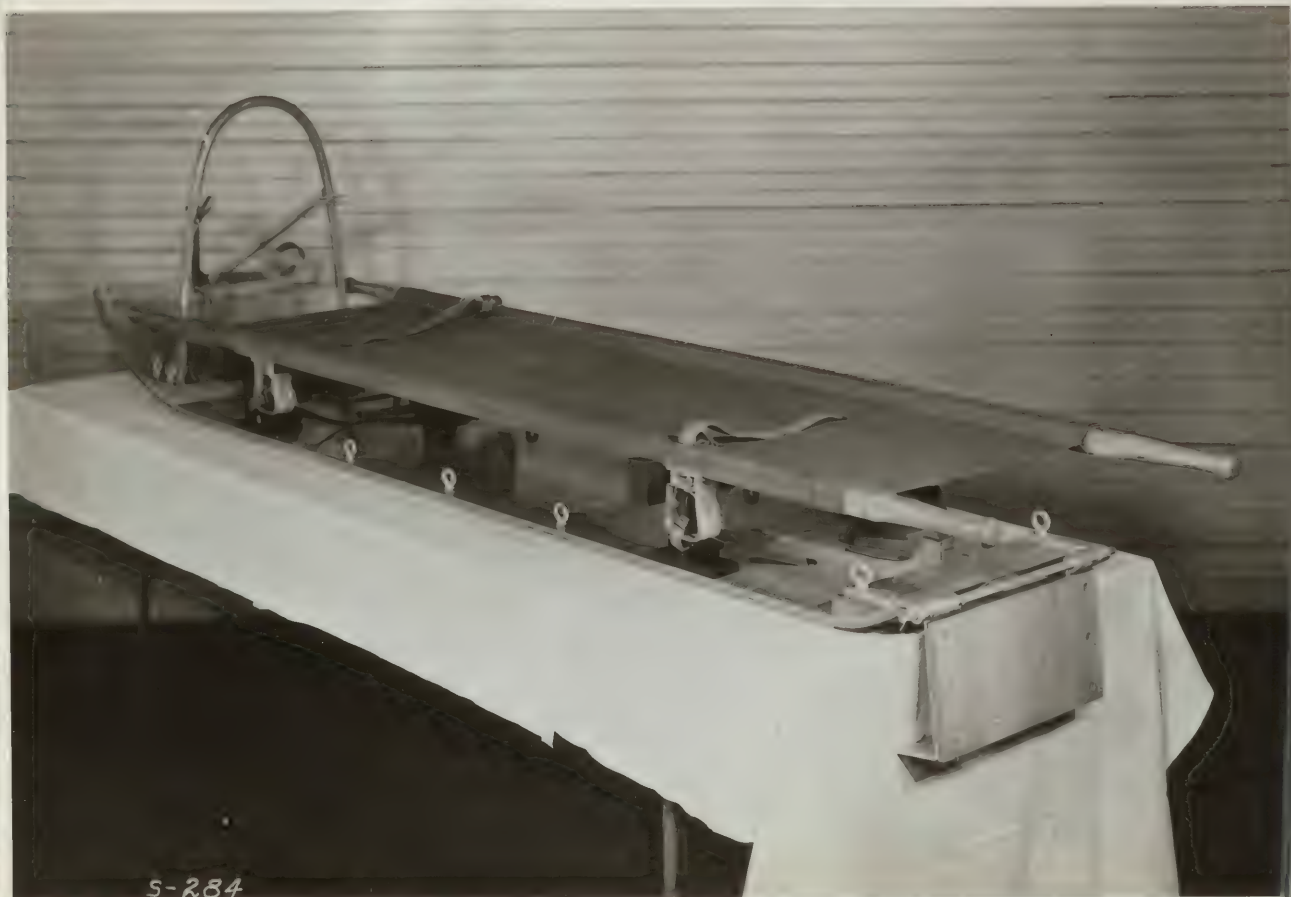
Arctic Rescue Unit, Air Corps (experimental) Dec. 1935.

The patient is covered with the blanket & shelter built
and held securely to the stretcher with the following



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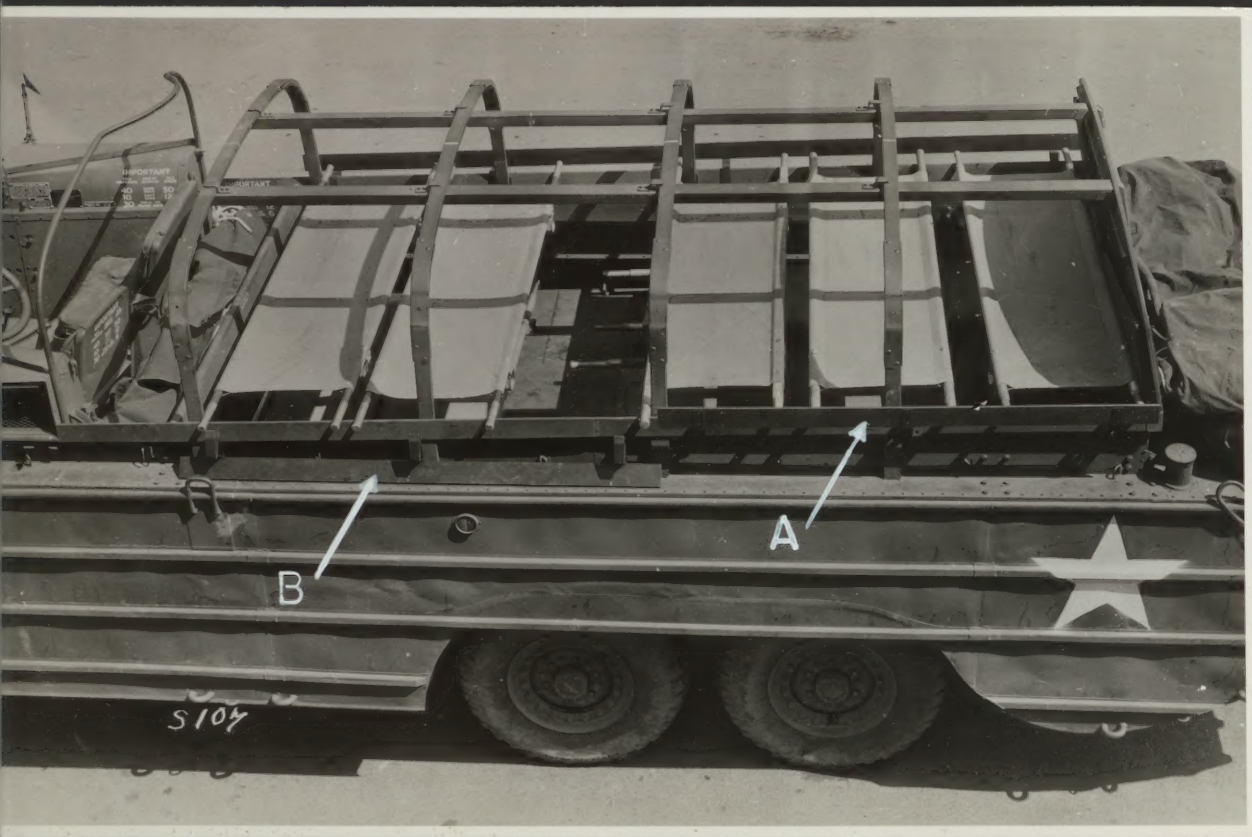


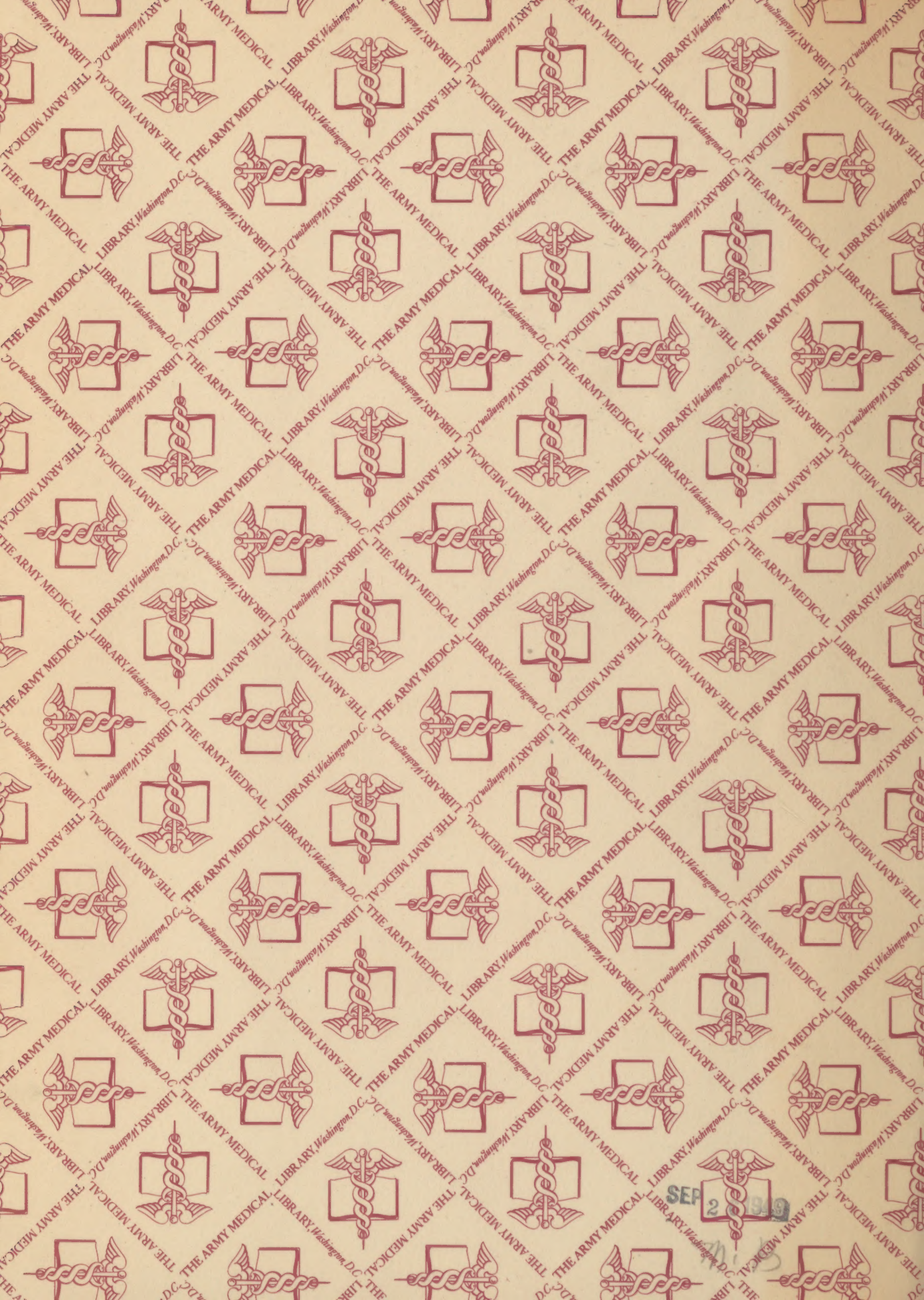


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